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Appendix D

GOBACK

Contents

Section I

INTRODUCTION

There are three programs in the set of computer programs called GOBACK. The purpose of these programs is to accept the coefficients of a curve or surface equation as produced by the linear programming formulation, and from these to calculate the basic loft information to produce the ship. The use of each of the three programs is given below.

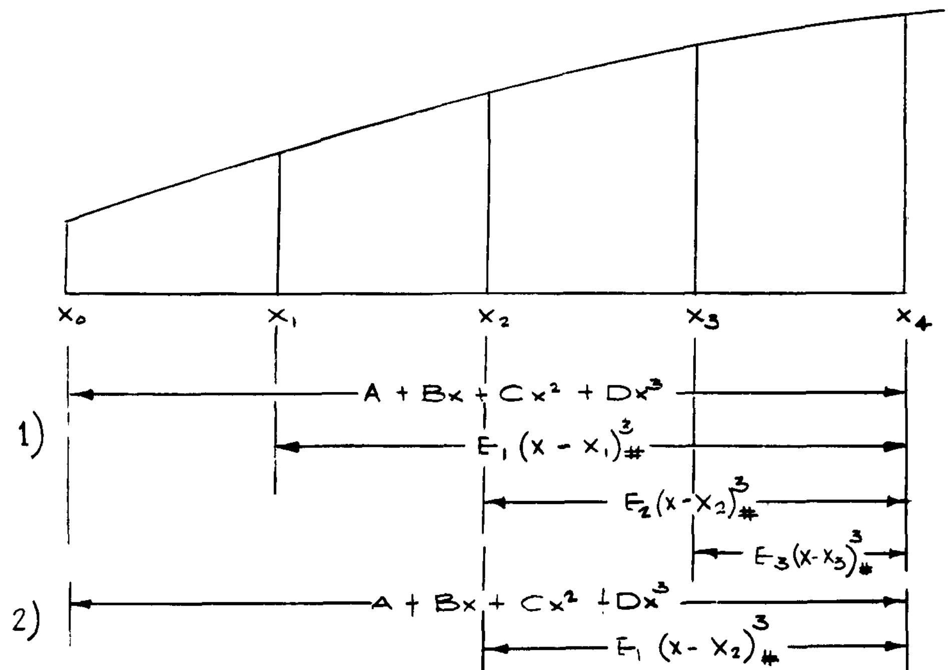
- GOBACK 1 - Calculates information from a surface equation which contains no profile requirements
- GOBACK 2 - Calculates information from a surface equation containing profile requirements
- GOBACK 3 - Calculates information from an equation describing a curve, and can plot the curve at the same time

Sections II and III of this Appendix describe the application of these programs. Section II describes the two-dimensional case handled by GOBACK 3, and Section III extends this to the three-dimensional case handled by GOBACK 1 and GOBACK 2 .

Section II

TWO DIMENSIONAL CASE

A typical curve which may require analysis is shown in Fig. D-1 The equations that may be used to describe the curve are also shown.



(1) $y = A + Bx - Cx^2 + D_x3 + E_1(x-x)^3_\# + E_2(x-x_2)^3_\# + E_3(x-x_3)^3_\#$

(2) $y = A + Bx + Cx^2 + Dx^3 + E_1(x-x_1)^3_\#$

\# See text ("Mathematical Ship Lofting - Part 1. Theory," Technical Report 1.0.0-1) for explanation of this notation.

Fig. D-1

Lines (1) describe the order and range of influence of the coefficients for a single splined equation. Lines (2) provide similar information for a double-splined equation. Note that the offset at x_o equals A and the equation goes exactly through that offset. GOBACK 3 is capable of providing offsets, first and second derivatives from these equations

Section III

SURFACE EQUATIONS

GOBACK 1 performs calculations from a three-dimensional surface equation such as that shown in Fig. D-2. This surface equation is an extension of the two-dimensional case. The surface equation is always double splined in the x direction (lengthwise on the ship). It may be either single or double splined in the z direction (vertical direction on the ship). The resulting equation for either representation is shown for a five-station by five-waterline surface in Fig. D-2.

The program has the ability to extract the following information from the surface equation:

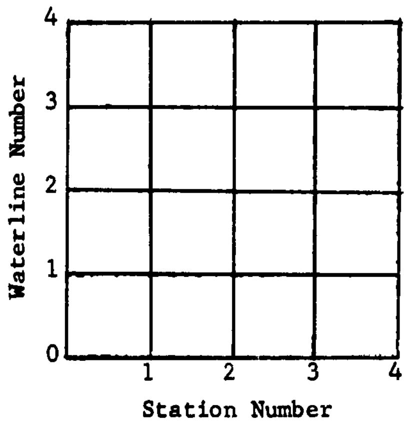
(1) The offset, and first and second derivatives, at any point on the surface

(2) The offsets, and first and second derivatives, along any waterline or station at any given increment or at an exact interval, such that straight lines joining the offsets will have its greatest deviation from the surface equal to a given tolerance.

(3) The Theilheimer equation, or the standard cubic equations for each interval, along any waterline or station.

(4) Heights and offsets at any interval along the intersection of the surface with any given spline curve.

(5) Heights and offsets at any increment along buttocks and diagonal planes.



Surface Equation (Double splined in x and z direction)

$$
\begin{aligned}
y = {} & A_{00} + A_{01}x + A_{02}x^2 + A_{03}x^3 + A_{04}(x-x_2)^3_{\#} \\
& + \left(A_{10} + A_{11}x + A_{12}x^2 + A_{13}x^3 + A_{14}(x-x_2)^3_{\#}\right) z \\
& + \left(A_{20} + A_{21}x + A_{22}x^2 + A_{23}x^3 + A_{24}(x-x_2)^3_{\#}\right) z^2 \\
& + \left(A_{30} + A_{31}x + A_{32}x^2 + A_{33}x^3 + A_{34}(x-x_2)^3_{\#}\right) z^3 \\
& + \left(A_{40} + A_{41}x + A_{42}x^3 + A_{43}x^3 + A_{44}(x-x_2)^3_{\#}\right) (z-z_2)^3_{\#}
\end{aligned}
$$

Surface Equation (Double splined in x , single splined in z direction)

$$
\begin{aligned}
y = {} & A_{00} + A_{01}x + A_{02}x^2 + A_{03}x^3 + A_{04}(x-x_2)^3_{\#} \\
& + \left(A_{10} + A_{11}x + A_{12}x^2 + A_{13}x^3 + A_{14}(x-x_2)^3_{\#}\right) z \\
& + \left(A_{20} + A_{21}x + A_{22}x^2 + A_{23}x^3 + A_{24}(x-x_2)^3_{\#}\right) z^2 \\
& + \left(A_{30} + A_{31}x + A_{32}x^2 + A_{33}x^3 + A_{34}(x-x_2)^3_{\#}\right) z^3 \\
& + \left(A_{40} + A_{41}x + A_{42}x^2 + A_{43}x^3 + A_{44}(x-x_2)^3_{\#}\right) (z-z_1)^3_{\#} \\
& + \left(A_{50} + A_{51}x + A_{52}x^2 + A_{53}x^3 + A_{54}(x-x_2)^3_{\#}\right) (z-z_2)^3_{\#} \\
& + \left(A_{60} + A_{61}x + A_{62}x^2 + A_{63}x^3 + A_{64}(x-x_2)^3_{\#}\right) (z-z_3)^3_{\#}
\end{aligned}
$$

Fig. D-2

A. WATERLINE AND STATION EQUATIONS

The equations for waterlines and stations may be extracted from the surface equation by setting x (for stations) or z (for waterlines) constant and summing coefficients. Using coefficients from equation (2), Fig. D-2, the equation for waterline 3 is found as follows by summing vertically with $z = 3$.

$$B_1 = A_{00} + A_{10}(3) + A_{20}(3)^2 + A_{30}(3)^3 + A_{40}(3-2)^3_{\#}$$

$$B_2 = A_{01} + A_{11}(3) + A_{21}(3)^2 + A_{31}(3)^3 + A_{41}(3-2)^3_{\#}$$

$$B_3 = A_{02} + A_{12}(3) + A_{22}(3)^2 + A_{32}(3)^3 + A_{42}(3-2)^3_{\#}$$

$$B_3 = A_{03} + A_{13}(3) + A_{23}(3)^2 + A_{33}(3)^3 + A_{43}(3-2)^3_{\#}$$

$$B_4 = A_{04} + A_{14}(3) + A_{24}(3)^2 + A_{34}(3)^3 + A_{44}(3-2)^3_{\#}$$

$$B_5 = A_{05} + A_{15}(3) + A_{25}(3)^2 + A_{35}(3)^3 + A_{45}(3-2)^3_{\#}$$

The equation for the waterline is:

$$y = B_1 + B_2x + B_3x^2 + B_4x^3 + B_5(x-x_2)^3_{\#}$$

The equation for a station is found by summing across in Equation 2, Fig. D-2. The equation for Station 2 is found as follows:

Set $x = 2$, then:

$$C_1 = A_{00} + A_{01}(2) + A_{02}(2)^2 + A_{03}(2)^3$$

$$C_2 = A_{10} + A_{11}(2) + A_{12}(2)^2 + A_{13}(2)^3$$

$$C_3 = A_{20} + A_{21}(2) + A_{22}(2)^2 + A_{23}(2)^3$$

$$C_4 = A_{30} + A_{31}(2) + A_{32}(2)^2 + A_{33}(2)^3$$

$$C_5 = A_{40} + A_{41}(2) + A_{42}(2)^2 + A_{43}(2)^3$$

The equation for the station is:

$$Y = C_1 + C_2z + C_3z^2 + C_4z^3 + C_5(z-z_2)^3_{\#}$$

B. STANDARD CUBIC EQUATIONS FOR WATERLINES AND STATIONS

Using the above two-dimensional equations we can now develop the standard cubic equations between each of the points where an additional coefficient is added. On single-spline curves there is one in every interval between offsets. On double-spline curves there will be a standard cubic between every odd numbered point (0 , 1 , 3 , ...) .

The following formulas are used to find the standard cubic equation on a waterline curve between the ith and ith_{+1} points of discontinuity. Using the waterline coefficients developed above:

$$D_1 = B_1 - \sum_{j=1}^{i} B_{j+4}\, x_j^3$$

$$D_2 = B_2 + 3\sum_{j=1}^{i} B_{j+4}\, x_j^2$$

$$D_3 = B_3 - 3\sum_{j=1}^{i} B_{j+4}\, x_j$$

$$D_4 = B_4 + \sum_{j=5}^{i+4} B_j$$

The equation is

$$y = D_1 + D_2 x + D_3 x^2 + D_4 x^3 \qquad x_j \leq x \leq x_{j+1}$$

Using the example of Fig. D-2 and the coefficients of Waterline 3, the standard cubic coefficients between points 2 and 4 would be:

$$D_1 = B_1 - B_5(1)^3$$

$$D_2 = B_2 + 3(B_5)(1)^2$$

$$D_3 = B_3 - 3(B_5)(1)$$

$$D_4 = B_4 + B_5$$

The standard cubic coefficients for an interval on a station are found in a similar manner. Using the station curve coefficients developed above, the coefficients between the i_{th} and $i_{th} + 1$ points of discontinuity are:

$$E_1 = C_1 - \sum_{j=1}^{i} C_{j+4} z_j^3$$

$$E_2 = C_2 + 3\sum_{j=1}^{i} C_{j+4} z_j^3$$

$$E_3 = C_3 - 3\sum_{j=1}^{i} C_{j+4} z_j$$

The equation is:

$$y = E_1 + E_2 z + E_3 z^2 + E_4 z^3$$

C. BUTTOCKS

The following procedure is used to obtain the heights of the intersection of buttock planes ($y = \text{constant}$) and the hull surface.

At each position along the length of a surface where a height is to be calculated, the two-dimensional equation for the frame is obtained, $y_f = f(z)$. The equation for the buttock is $y_B = C$, where C is the distance from the centerplane. Subtracting the two equations gives:

$$\delta y = y_f - y_b = f(z) - C$$

Trial and error solution until $|\delta y| \leq \varepsilon$, where ε is a small number provides the correct value of z .

D. DIAGONAL PLANES

It is sometimes of interest to calculate the intersections of diagonal planes with the surface. GOBACK 1 has the capability of handling diagonal planes which pass through the intersection of the centerline plane and a waterline and whose intersection with the hull surface is below that waterline (Fig. D-3)

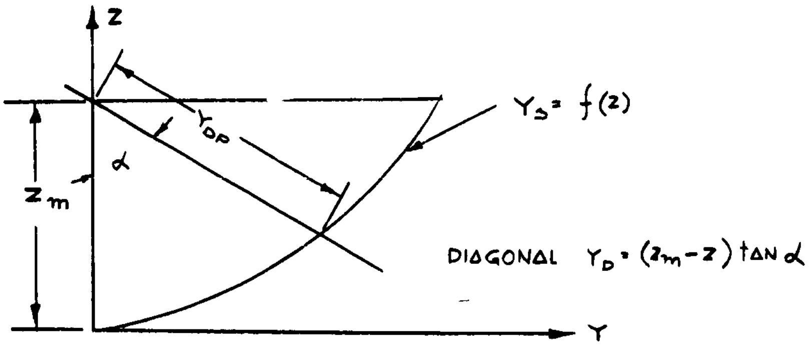


Fig. D-3

The procedure is similar to that used in finding heights of the intersection of the surface and buttock. First, the equation for the frame is found, then the equation for the plane is subtracted from it, giving:

$$\delta y = y_s - y_d = f(z) - \tan x\ (z_m - z)$$

The equation is solved for z by trial and error.

E. SEGMENTATION OF WATERLINES AND FRAMES

It is frequently necessary, primarily for purposes of numerical control, to be able to approximate waterline and station curves with straight lines such that the deviation between curve and line is no greater than some given tolerance. The GOBACK 1 program has the ability to segment a station or waterline curve so the greatest deviation will always be exactly the specified tolerance. A development of the method used is given below.

For the purposes of the development, a waterline curve has been selected. The method applies equally well to a station curve.

Figure D-4 shows the geometry of the problem.

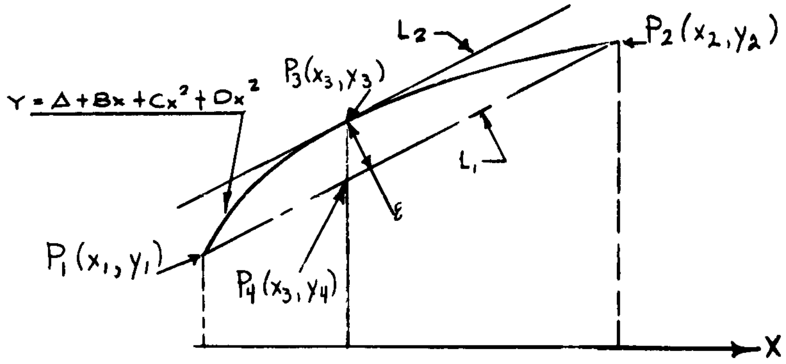


Fig. D-4

Statement of the problem:

Given curve $y = f(x) = A + Bx + Cx^2 + Dx^3$, a point on that curve P_1 and a tolerance $\mathcal{E}_1$; find a point on the curve P_2 , with a greater x coordinate, such that a line joining P_1 and P_2 will have its greatest deviation from the curve equal to $\mathcal{E}$.

As shown in Fig. D-4, the greatest deviation from the chord (L_1) occurs at the point (P_3) where the tangent to the curve (L_2) is parallel to the chord. The slope of the tangent at this point $m_1 = f'(x)$ evaluated at x_3 , which is equal to the slope of the chord

The equations for these lines are:

$$L_1 , \quad Y - Y_1 = m_1 \left[x-x_1\right]$$

$$L_2 , \quad Y - Y_3 = m_1 \left[x-x_3\right]$$

or

$$L_1 , \quad Y = Y_1 + m_1 x - m_1 x_1$$

$$L_2 , \quad Y = Y_3 + m_1 x - m_1 x_3$$

Now let

$$C_1 = Y_1 - m_1 x_1$$

$$C_2 - Y_3 - m_1 x_3$$

now the length of the line joining P_3 and P_4 equals

$$C_1 - C_2 = \frac{\mathcal{E}}{\cos(\tan^{-1} m_1)}$$

Therefore
$$\mathcal{E} = \frac{Y_3 - Y_1 - m_1 x_3 + m_1 x_1}{\left[1 + m_1^2\right]^{\frac{1}{2}}}$$

Substituting the equation for y_3, its first derivative for m_1 and rearranging gives:

$$\mathcal{E}\left[1 + (B + Cx_3 + Dx_3^2)^2\right]^{\frac{1}{2}} = (A - y_1 + Bx_1) + (2Cx_1)\, x_3 + (3Dx_1 - C)\, x_3^2 - 2Dx_3^3$$

x_3 is the only unknown in this equation. It may be solved by trial and error to yield x_3.

Substituting x_3 into the first derivative of the equation of the curve yields the slope at that point m_1.

Now from the equation for L_1

$$Y_2 = Y_1 + m_1\,(x_2 - x_1)$$

And from the equation of the curve

$$Y_2 = A + Bx_2 + Cx_2^2 + Dx_2^3$$

Subtracting

$$0 = Y_1 + m_1\,(x_2 - x_1) - \left[A + Bx_2 + Cx_2^2 + Dx_2^3\right]$$

This equation may now be solved for its only unknown, x_2, by trial and error.

Finally substituting x_2 in the equation for the curve gives:

$$y_2 = A + Bx_2 + Cx_2^2 + Dx_2^3$$

Note that we have assumed in this derivation that $f(x)$ is a standard cubic equation. GOBACK 1 solves for the standard cubic equation coefficients in each interval before segmenting the curve.

F. INTERSECTIONS WITH CURVES

It is frequently necessary to find intersections of the hull surface equation $y = f(x,z)$ with previously defined curves. For example, to find offsets of sight edges or longitudinals.

The curves are usually defined by a faired Theilheimer equation $z = G(x)$ representing the trace of the heights of the curve on the centerplane of the ship. To find the intersection of the curve with a given frame, GOBACK first solves $G(x)$ at the given x of the frame for the height z, then plugs x and z in $f(x,z)$ to obtain the offset y. The curve $G(x)$ must have the same origins and be scaled the same as $f(x,z)$,

Although GOBACK expects a form for $z - G(x)$, such as:

$$z = A + Bx + Cx^2 + Dx^3 - E_1 (x-x_1)_{\#}^3 + \dots ,$$

it is clearly possible to use degenerates of this function, such as $z = Cx^2$ by making the other coefficients zero.

Section IV

SURFACE EQUATION WITH END CONDITIONS

When the surface which has been faired contains an end profile, the equation requires a special function which guarantees that the surface will assume the shape of the profile. The profile function has the effect of squeezing the surface down to the required profile. This function usually is effective up to about one station space from the profile.

The surface equation now becomes

$$y(x,z) = F(x,z) \cdot T(x,z)$$

where $F(x,z)$ is the original surface equation and $T(x,z)$ is the profile function.

The function equals:

$$T(x,z) = \left[1 - \left(\frac{D + G(z) - x}{D}\right)_{\#}^{3}\right]_{\#}^{P}$$

where $G(z)$ is a two-dimensional Thielheimer equation of the profile. $G(z)$ has the same origin and is scaled the same as the surface equation. D is the fraction of the station spacing over which the function is effective and P determines if the slope at the profile is finite or infinite. If P has a value 1 the slope is finite , a value of 1/3 would give infinite slope.

A. EQUATIONS FOR WATERLINES AND STATIONS

The equations for waterlines and stations are obtained in the same manner as in GOBACK 1 . Offsets are obtained from these equations

in the same manner as GOBACK 1, except a value for the end profile function must be found and the result multiplied by it. This is done by GOBACK 2 . First and second derivatives are calculated as shown in Appendix B.

B. BUTTOCKS

Because the GOBACK 2 program is required to calculate data in the extreme ends of the ship, a somewhat more sophisticated routine for finding buttocks was included in it.

As shown in Fig. D-5 the buttock for a ship can be single, double, or triple valued on any given station. Also, different buttocks on the same ship are different cases.

If the hull shape is such that the case shown in Fig. D-5a can be guaranteed, the program will calculate buttocks as shown in Section III.

If there is a possibility that one of the other cases is present, the following procedure is used.

(1) The equation of the frame is calculated from the surface equation.

(2) The intersection of the frame with the baseline is found (y_q) .

(3) The coordinates of Point P (y_p, z_p) are found by examining the slope of the curve at intervals starting at the baseline until the slope changes from negative to positive. The Point P is the exact point on the curve where this takes place. If no point P is found, then this is also

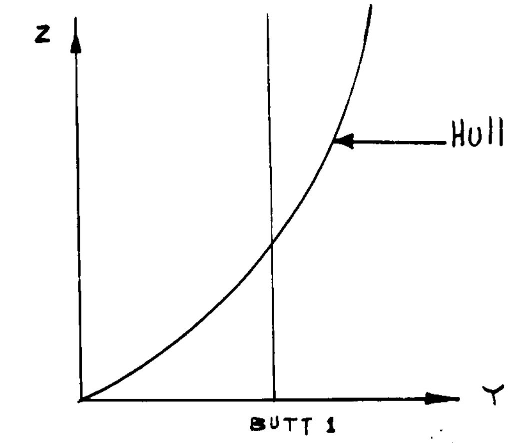


FIG. D-5-a

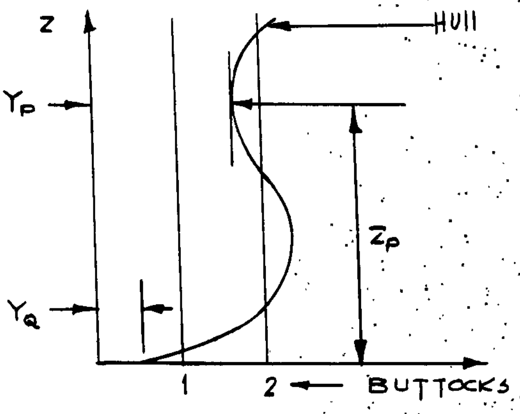


FIG. D-5-b

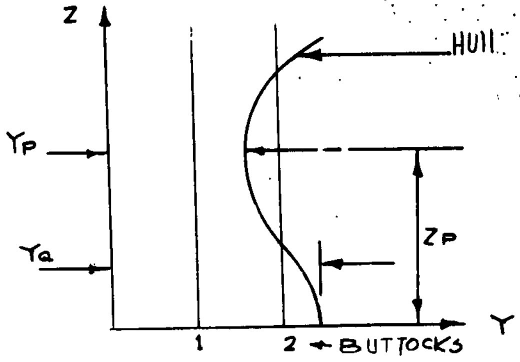


FIG. D-5C

Fig. D-5

the case shown in Fig. 5-a .

(4) The values y_q and y_p and compared with the y value of the buttock plane (y_b) .

If:

$y_q < y_b < y_p$ the case is that of buttock 1 Fig. 5-b and only one intersection will be found

$y_q < y_b > y_p$ the case is that of buttock 2 Fig 5-b, and three intersections must be checked for.

$y_q > y_b < y_p$ the case is that of buttock 1 of Fig. 5-c and no intersections are present

$y_q > y_b > y_p$ the case is shown as buttock 2 Fig. 5-c, and two intersections may be present.

(5) The coordinates of the intersections themselves are found by finding a trial and error solution of the frame equation minus the buttock equation.

The first frame cut for a given buttock line is found by finding the intersection of the buttock with the uppermost waterline on the surface. From this point, frame cuts are made at a specified interval along the ship, and the intersections of each frame with the buttock is found.

Section V

GOBACK 1

A. OPERATING INSTRUCTIONS

This version of GOBACK will accept coefficients of a surface equation such as shown in Fig. D-2 which does not have end profile requirements. The equation must be single splined in the x direction and may be single or double splined in the z direction.

The following data can be calculated with this program:

— Offsets, first and second derivatives along a waterline at a given interval or at an interval determined by a tolerance

— Offsets, first and second derivatives along a station at a given interval or at an interval determined by a tolerance

— Standard cubic coefficients for each section of a waterline

— Standard cubic coefficients for each section of a station

— Offsets at a given interval along buttocks

— Offsets at a given interval along diagonal planes

Fortran Input Symbols

Symbol		Definition
XO	-	The actual full scale coordinate of the first station of the surface
ZO	-	The actual full scale Z coordinate of the first waterline of the surface
FINTX	-	This value is used as a scale factor in the x direction. If the surface equation is scaled so the stations are one unit apart, FINTX equals the actual full scale station interval (x_1-X_0). If

the stations of the surface equation are less than one unit apart, FINTX becomes some multiple of the station spacing. For example, if the stations in the equation are 1/4 unit apart, FINTX becomes four times the actual full-scale station spacing $\left[4(x_1 - x_o)\right]$

FINTZ - Same definition as FINTX, except in the Z direction $(z_1 - z_0)$

M - The total number of points of discontinuity along a station (points where z coefficients are added) including the points at the first and last waterlines. For example, if a surface containing seven waterlines were single splined, M would equal seven, since there are third derivative discontinuities at each waterline. If the seven-waterline surface were double splined, M would equal four, since there are discontinuities only at waterlines 0 , 2 , 4 , and 6.

N - The total number of points of discontinuity along a waterline (points where x coefficients are added). The example used for M is valid except using stations instead of waterlines.

SEGX - Desired interval between consecutive calculated offsets along waterlines, buttocks, and diagonal planes.

SEGZ - Desired interval between consecutive calculated offsets along stations.

KS - The value SEGX can be changed when working along a curve in the x direction. KS is the number of changes to be made.

XS - The x distance from the origin of the surface to a point where SEGX is to be changed. This must coincide with a station or a specific point (see definition of K).

SEGXS - Value to which SEGX is to be changed when XS is reached.

A - Coefficients of the surface equation produced by linear program. There are (M+2)(N+2) coefficients.

Z - z coordinates of waterlines where coefficients are added, plus that of the last waterline. There are (M-1) since the value for the first waterline isn't included.

X - Same as Z except for stations (N-1)

IDENT - Code which tells the program what data is required from the surface (See Input Format description)

K - The program makes a provision for obtaining offsets at specific distances along a curve which may not coincide with the intervals specified by SEGX or SEGZ. These are called "specific points." K is the number of points asked for along a curve.

ZT - The z coordinate of a waterline along which data is to be calculated.

XT - The x coordinate of a station or frame along which data is to be calculated.

NN - A symbol consisting of two letters used to identify specific points in the output. The same symbol must be used for all specific points on any one curve (see ISP below)

ISP - A companion symbol to NN providing two additional characters for identification. For example, if the specific point on a station corresponded to longitudinal 13, NN might become LG and ISP become 13, as the specific point would be identified LG13.

XE	-	The x coordinate of specific points on waterlines, diagonals, and buttocks (see definition of K).
ZE	-	Same as XE except for stations
ANGLE	-	The angle (α in Fig. D-3) between a diagonal plane and the vertical centerplane of the ship.
BUTTK	-	The y distance from the centerplane of the ship to a buttock along which heights are to be calculated
SX	-	The starting point on a curve when segmenting with a tolerance in the x direction
SZ	-	The starting coordinate when segmenting a station according to a tolerance
FX	-	The finish coordinate corresponding to SX
FZ	-	The finish coordinate corresponding to SZ
TOL	-	The maximum deviation between a curve and the straight line segments approximating it when segmenting according to a tolerance.

Input Data Cards

There are two distinct kinds of sets of data used for input to GOBACK 1 . The first set consists entirely of data describing the surface equation to the program. No output is produced from this set. The second set of data consists of packets of data cards. Each packet describes some information required from the surface and gives the geometric data necessary to obtain the information from the surface equation. Only one of the first sets of data are entered per problem. There may be many small packets, each of

calls for offsets along a waterline or station, or perhaps standard cubic coefficients etc.

There are limitations on some of the input parameters of the program. These limitations follow.

Variable	Minimum	Maximum
M	3	20
N	3	40
K (no. of specific points/curve)	0	20

In describing the various data cards, the actual FORTRAN format field description is used in most cases. These fields come consecutively across the card with no gaps or blank columns between. The field descriptions are the FORTRAN F field which uses the FORTRAN fixed point decimal number, and the I field that used the FORTRAN integer number which is always right justified. The card numbers are <u>not</u> punched on the data cards.

<u>First Data Set</u>

This data set is the one that describes the surface equation

Contents of Card							Card No.
The first card is a header card and may contain any alphanumeric description of the problem in Columns 1-50							1
Format	F15.8	F15.8	F15.8	F15.8	I5	I5	2
Variable	XO	ZO	FINTX	FINTZ	M	N	
Format	F15.8	F15.8	F15.8				3
Variable	SEGX	SEGZ	KS				
Format	F15.8	F15.8					next
Variable	SEGXS	XSEG					KS cards
Format	F15.8						next
Variable	A						(M+2)(N+2) cards

Format	F15.8	next
Variable	Z	(M-1)cards
Format	F15.8	next
Variable	X	(N-1) cards

This completes the first data set.

The coefficients of the surface equation (A) are presented in the following order (see Fig. D-2):

$$A_{00} , A_{01} , A_{02} , A_{03} , A_{04} , \cdots , A_{10} , A_{11} , A_{12} , A_{13} ,$$

$$A_{14} , \cdots , A_{20} , A_{21} , A_{22} , A_{23} , A_{24} , \cdots , A_{31} , A_{32} ,$$

$$A_{33} , A_{34} , \cdots , A_{40} , \cdots , \dots\dots\dots .$$

This is generally the order in which they will be received from the L.P. Coefficient A_{00} is the constant term for the equation. It is equal to the preliminary offset of the first point on the surface (x_0 , z_0) . Any coefficients that weren't in the final solution must have a zero value included in the data deck.

Second Data Set

This data set contains the packets of cards, each of which describes some information to be extracted from the surface. Any number of these packets may be used in a problem. They may be entered in any desired order by simply stacking them behind the first data set in the card reader. A description of each data packet follows. The first card for each of these packets is an identification card and contains a specific value of IDENT in Column 4 .

Packet for Offsets on a Waterline

Contents of Card	Card No.
The first card is the identification card and contains a 1 in Column 4.	1
Format I4 F15.8 Variable K ZT	2
Format I2 I3 3X F15.8 Variable NN ISP 3 blank Cols. ZE	next K cards

(This set of K cards contains the identification and location of any specific points. They are to be arranged so the smallest ZE is the first card progressing in order to the largest ZE in the last one)

Packet for Offsets of a Station

Contents of Card	Card No.
This card has a 2 in Column 4	1
Format I4 F15.8 Variable K XT	2
Format I2 I3 3X F15.8 Variable NN ISP 3 blank Cols. ZE	next K cards

(Begin with the smallest ZE and progress to largest)

Packet for Offsets of a Diagonal Plane

Contents of Card	Card No.
This card contains a 3 in Column 4	1
Format F15.8 Variable ANGLE	2

Packet for Offsets of a Buttock

Contents of Card	Card No.
This card contains a 4 in Column 4	1
Format F15.8 Variable BUTTK	2

Packet for Standard Cubic Coefficients on a Waterline

Contents of Card					Card No.
This card contains a 5 in Column 4					1
Format	F15.8				2
Variable	XT				

Packet for Standard Cubic Coefficients on a Station

Contents of Card					Card No.
This card contains a 6 in Column 4					1
Format	F15.8				2
Variable	XT				

Packet for Segmentation of a Waterline

Contents of Card					Card No.
This card contains a 7 in Column 4					1
Format	F15.8	F15.8	F15.8	F15.8	2
Variable	ZT	SX	FX	TOL	

Packet for Segmentation of a Station

Contents of Card					Card No.
This card contains an 8 in Column 4					1
Format	F15.8	F15.8	F15.8	F15.8	2
Variable	XT	SZ	FZ	TOL	

Output Data

The output data for the different types of information requested is given below. When this output data consists of offsets of curves which may need to be plotted, GOBACK 1 includes cards which place the plotter pen up or down at the proper times. The data deck is arranged in order and punched in such a format that the deck can be directly plotted using the plotting program of Appendix F.

Offsets of a Waterline

The first N+2 cards punched when the offsets of a waterline are called for contain the coefficients for the two-dimensional Thielheimer equation of the waterline. Following this is a header card and finally cards each containing:

(1) A waterline identification number (WL)
(2) The x coordinate of the offset
(3) The offset on the waterline
(4) The first derivative of the waterline
(5) The second derivative of the waterline

Offsets of a Station or Frame

Information corresponding to that of a waterline is punched. The frame identification (FR) and the z coordinate of the offset are given.

Offsets of a Diagonal Plane

First, a header card is punched and then cards containing the following data:

(1) An identification of the diagonal plane (DP)
(2) The x coordinate of the offsets
(3) The z coordinate of the offset
(4) The offset y_{dp} as shown in Fig. D-3

Offsets of a Buttock

First, a header card is punched and then cards containing the following:

(1) An identification of the buttock (BK)
(2) The x coordinate of the point is given
(3) The z coordinate of the point is given

Standard Cubic Coefficients for a Waterline

The first card punched contains an identification of the waterline. Following this are a set of N cards, each of which contains the following information for an interval along the waterline:

(1) The coefficients A,B,C,D, of the cubic

(2) The starting and ending x coordinates of the interval.

Standard Cubic Coefficients of a Frame

The same data is given as for a waterline, except that there are M intervals and the z coordinates of the start and finish of an interval are given.

Segmentation of a Waterline to a Tolerance

First, a header card is punched. Then cards containing the following information are punched:

(1) The identification of the waterline

(2) The x coordinate of the offset

(3) The offset

(4) The tolerance

Segmentation of a Station to a Tolerance

The same information is punched as for a waterline, except the z coordinate of the offset is given.

Sense Switches

Sense Switch 4 ON - No second derivatives are punched for waterlines or stations

Sense Switch 4 OFF - Whenever an offset is punched on a waterline or station the second derivative is punched

All other sense switches are ignored.

B. SAMPLE PROBLEM

The sample problem is a seven station by eight waterline surface from the DE-1037 class ships. The stations were 5 through 11 and the waterlines were the 4' through 32'. The surface was single splined in the z direction.

Offsets were calculated for one frame, one waterline, and one buttock. Standard cubic equations were found for one waterline and one frame, and the heights and halfbreadths of the intersection of the 01 level and the surface were found.

B. **SAMPLE PROBLEM FOR GOBACK 1**

* * SAMPLE INPUT * *

```
                    DE 1037
  87.5              4.              35.            8.            8
 4
 20.                4.               3
  2.5                107.5
   1.               150.
   41.5             151.
  7.395835
3.4021024
.43256810
-.23899897
-.05975052
.30222755
 8.5007951
-45.380311
86.461133                      Coefficients of the surface equation
-37.816704
45.392666
23.518814
-12.388975
164.50268
-298.36348
129.49442
-154.92941
-79.080046
8.2593167
  -139.79112
252.23775
-109.53571
131.40512
64.742903
-8.8703614
176.86673
-320.34323
139.37182
-167.77884
-77.970667
1.4378967
-46.174359
85.877451
```

```
-37.57123
45.564253
14.238035
-1.0426593
12.468567
-22.614727
9.4637234
-10.732676
.15734228
.72400226
-6.8605798
9.8515627
-3.6732793
4.0526781
-3.8607566
-.79698505
4.5303580
-6.1544445
2.3878876
-3.2185290
3.8711793
.06938527
12.769376
-20.364931
8.1774277
-9.6133634
1.0232311
         8.
         12.
         16.
         20.
         24.
         28.
         32.
```

Waterline where new z coefficients are to be added (z)

```
         122.5
         157.5
         192.5
```

Stations where new x coefficients are to be added (x)

First Data Set

Second Data Set

```
    4    30.
FR  1     107.5
FR  2     115.
FR  3     150.
FR  4     151.
    2
    3    145.
ST  3        25.52666
ST  2        27.02666
```

```
ST  1       28.52666
  3
 45.0
  4
 8.0
  5
 30.
  6
 145.
  7
 30.             130.            170.            .001
  8
145.              17.             26.            .001
  9
 0-1 LEVEL
 30.56853
 -.1967334
 -.13065
 .06418331
 -.072799998
 0.
```

* * SAMPLE OUTPUT * *

DE 1037 -

15.08539200
2.56392320
.00166476
-.29505930
.53263620
-.45633232

IDENT.	X	Y	FIRST DER.	SECOND DER.
WL 30.00	87.50000000	15.08539200	.07325494	.00000271
PEN DOWN	5000.00000000			
FR 1	107.49999000	16.49597900		
FR 2	114.99999000	16.95781000		
WL 30.00	122.50000000	17.35592000	.04805928	-.00144247
WL 30.00	127.49999000	17.57887700	.04046389	-.00127623
WL 30.00	147.49999000	18.19321000	.01573200	-.00061129
FR 3	149.99999000	18.24735500		
FR 4	150.99999000	18.26805900		
WL 30.00	157.50000000	18.39205900	.01793654	-.00027882
WL 30.00	167.49999000	18.55238000	.03746109	-.00058495
WL 30.00	187.49999000	18.66692400	.13486811	-.00119721
WL 30.00	192.50000000	18.63029900	.17204520	-.00135028
PEN UP	6000.00000000			
GO TO	87.50000000	18.63029900		

13.07689200
11.68305200
-14.38853300
8.61199300
-9.49738800
2.87433700
-2.48411930
.83143300
-.23205720
-.21185000

IDENT.	Z	Y	FIRST DER.	SECOND DER.
FR 145.00	4.00000000	13.07689200	1.46038150	-.44964165
PEN DOWN	5000.00000000			
FR 145.00	8.00000000	16.39778400	.46918918	-.04595448

FR 145.00	12.00000000	17.79623100	.64755556	-.08745737
FR 145.00	16.00000000	18.15465200	-.09573533	.00577428
FR 145.00	20.00000000	18.29494700	-3.87459450	-.01743714
FR 145.00	24.00000000	18.26018300	-13.09499600	-.00167504
ST 3	25.52666000	18.22452200		
ST 2	27.02666000	18.18990000		
FR 145.00	28.00000000	18.16960000	-30.13434200	.00320919
ST 1	28.52666000	18.15974900		
FR 145.00	32.00000000	18.10387900	-57.38450500	-.00183689
PEN UP	6000.00000000			
GO TO	4.00000000	18.10387900		
IDENT.	X	Y	Z	
DP 45.00	87.50000000	17.30200700	19.76562500	
PEN DOWN	5000.00000000			
DP 45.00	107.49999000	20.43979100	17.54687500	
DP 45.00	122.50000000	22.77103300	15.89843700	
DP 45.00	142.49999000	25.27905000	14.12500000	
DP 45.00	157.50000000	26.59382700	13.19531200	
DP 45.00	177.49999000	27.78706900	12.35156200	
DP 45.00	192.50000000	28.17376800	12.07812400	
PEN UP	6000.00000000			
GO TO	87.50000000	12.07812400		
IDENT.	X	Z		
BK 8.00	87.50000000	4.64062500		
PEN DOWN	5000.00000000			
BK 8.00	107.49999000	4.00000000		
BK 8.00	122.50000000	4.00000000		
BK 8.00	142.49999000	4.00000000		
BK 8.00	157.50000000	4.00000000		
BK 8.00	177.49999000	4.00000000		
BK 8.00	192.50000000	4.00000000		
PEN UP	6000.00000000			
GO TO	87.50000000	4.00000000		

WL 30.00

A	B	C	D	START	FINISH
15.08539200	.07325494	.00000135	-.00000688	87.500	122.500
14.55275600	.11890948	-.00130305	.00000554	122.500	157.500
18.20341400	-.03754730	.00093204	-.00000510	157.500	192.500

FR 145.00

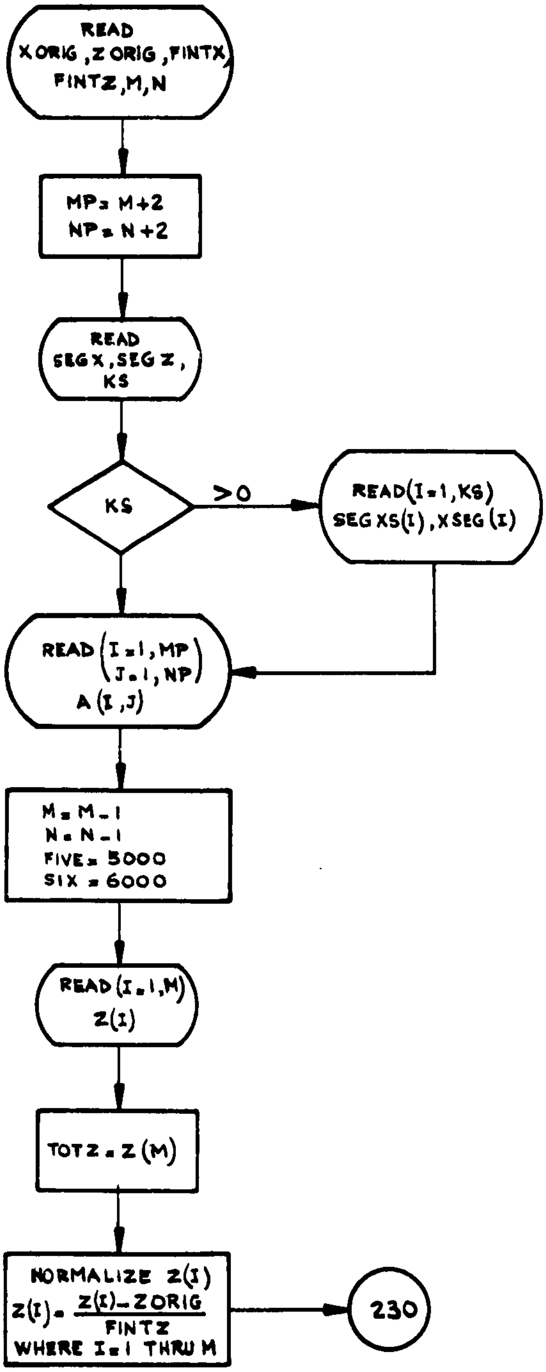
A	B	C	D	START	FINISH
13.07689200	1.46038150	-.22482082	.01682029	4.000	8.000
14.26406500	.57000137	-.00222579	-.00172928	8.000	12.000
11.38972800	1.64787770	-.13696034	.00388465	12.000	16.000
19.77363000	-.44809775	.03770428	-.00096714	16.000	20.000
13.12216600	.79905175	-.04024256	.00065674	20.000	24.000
16.74805900	.25516768	-.01304835	.00020351	24.000	28.000
22.46800900	-.45982606	.01674304	-.00021025	28.000	32.000

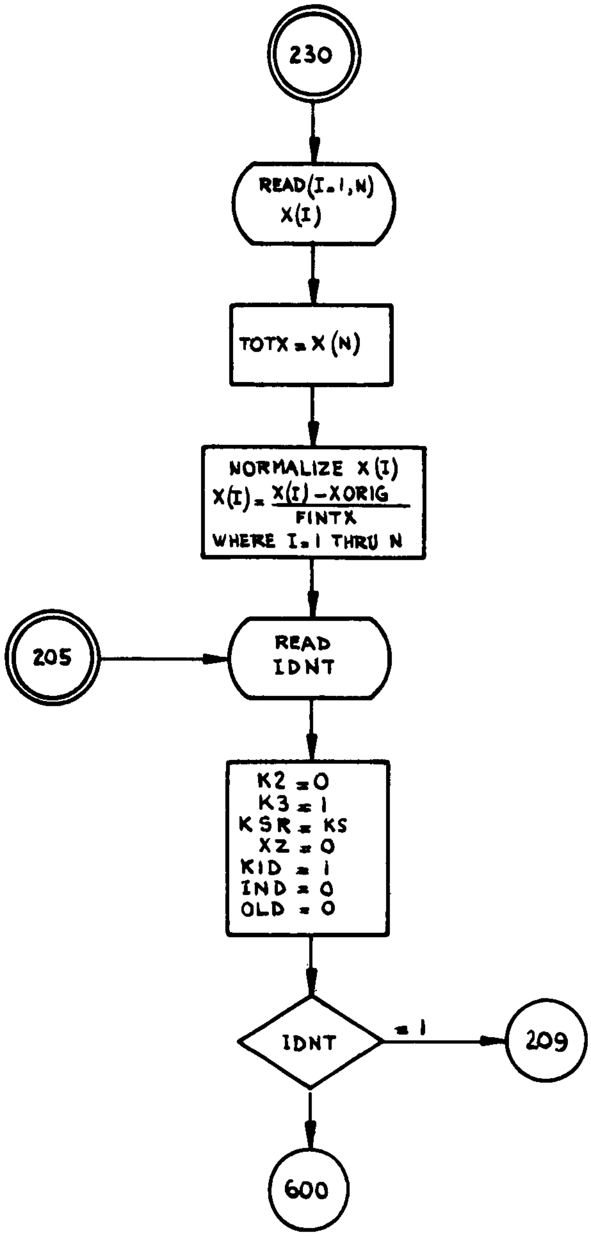
IDENT.		X	Y	TOLERANCE
WL	30.00	129.99999000	17.67813200	.00100000
WL	30.00	132.63960000	17.77484800	.00100000
WL	30.00	135.38715000	17.86734600	.00100000
WL	30.00	138.26559000	17.95605100	.00100000
WL	30.00	141.30284000	18.04141700	.00100000
WL	30.00	144.54118000	18.12415200	.00100000
WL	30.00	148.04749000	18.20537800	.00100000
WL	30.00	151.93962000	18.28706100	.00100000
WL	30.00	156.47632000	18.37354600	.00100000
WL	30.00	157.50000000	18.39205900	.00100000
WL	30.00	162.26849000	18.47386700	.00100000
WL	30.00	166.32337000	18.53596100	.00100000
WL	30.00	169.96221000	18.58406100	.00100000
WL	30.00	169.99999000	18.58451700	.00100000
IDENT.		Z	Y	TOLERANCE
FR	145.00	17.00000000	18.19557000	.00100000
FR	145.00	18.38721400	18.25104600	.00100000
FR	145.00	19.25546800	18.27884000	.00100000
FR	145.00	19.98029800	18.29463200	.00100000
FR	145.00	20.00000000	18.29494300	.00100000
FR	145.00	20.70570100	18.30189200	.00100000
FR	145.00	21.48541600	18.30114000	.00100000
FR	145.00	22.38815800	18.29159400	.00100000
FR	145.00	23.56892300	18.26968400	.00100000
FR	145.00	24.00000000	18.26017000	.00100000
FR	145.00	24.58768000	18.24666900	.00100000
FR	145.00	26.00000000	18.21334600	.00100000

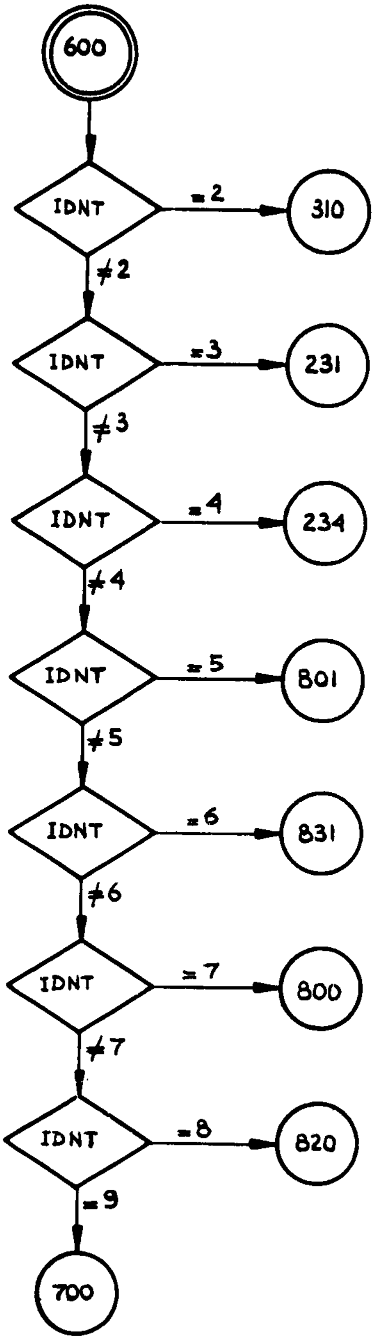
O-1 LEVEL

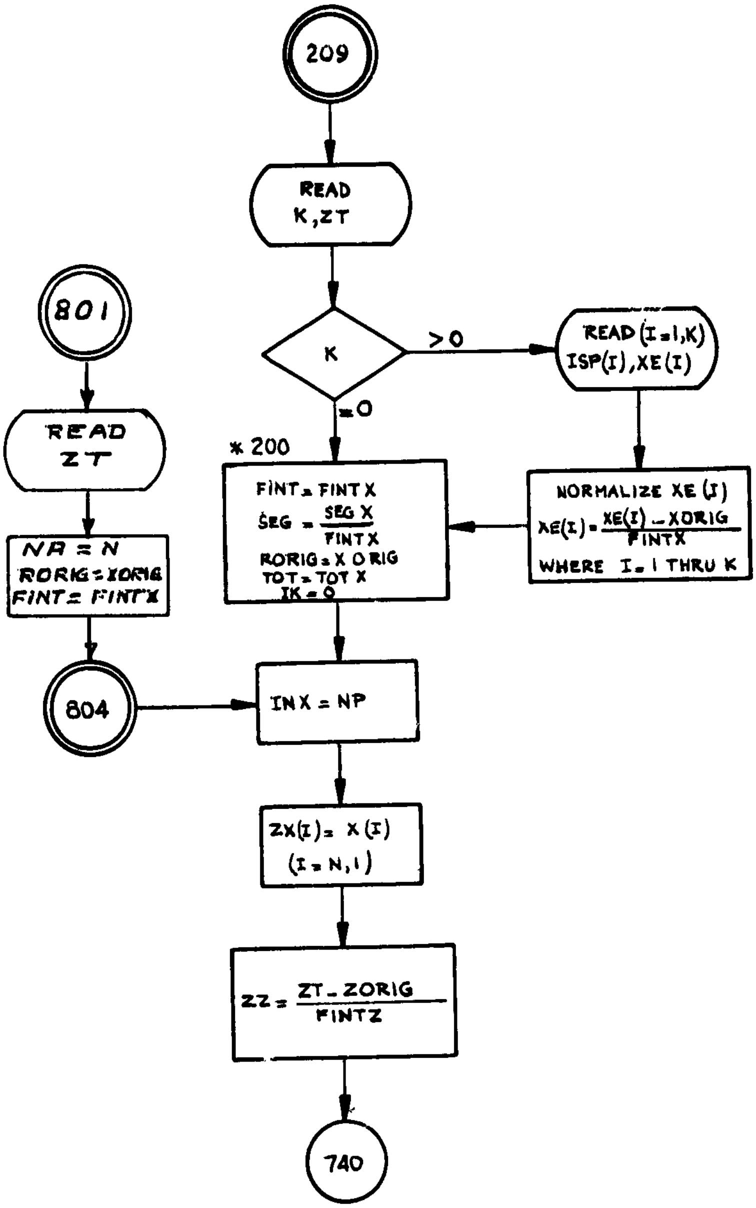
X	Z	Y
87.50000000	30.56853000	15.28253600
107.49999000	30.42542500	16.59634800
122.50000000	30.30533000	17.39770100
127.49999000	30.26864300	17.60595300
147.49999000	30.14414200	18.18858100
157.50000000	30.09313100	18.38372500
167.49999000	30.04800600	18.54872600
187.49999000	29.97059000	18.67598500
192.50000000	29.95303000	18.63659300

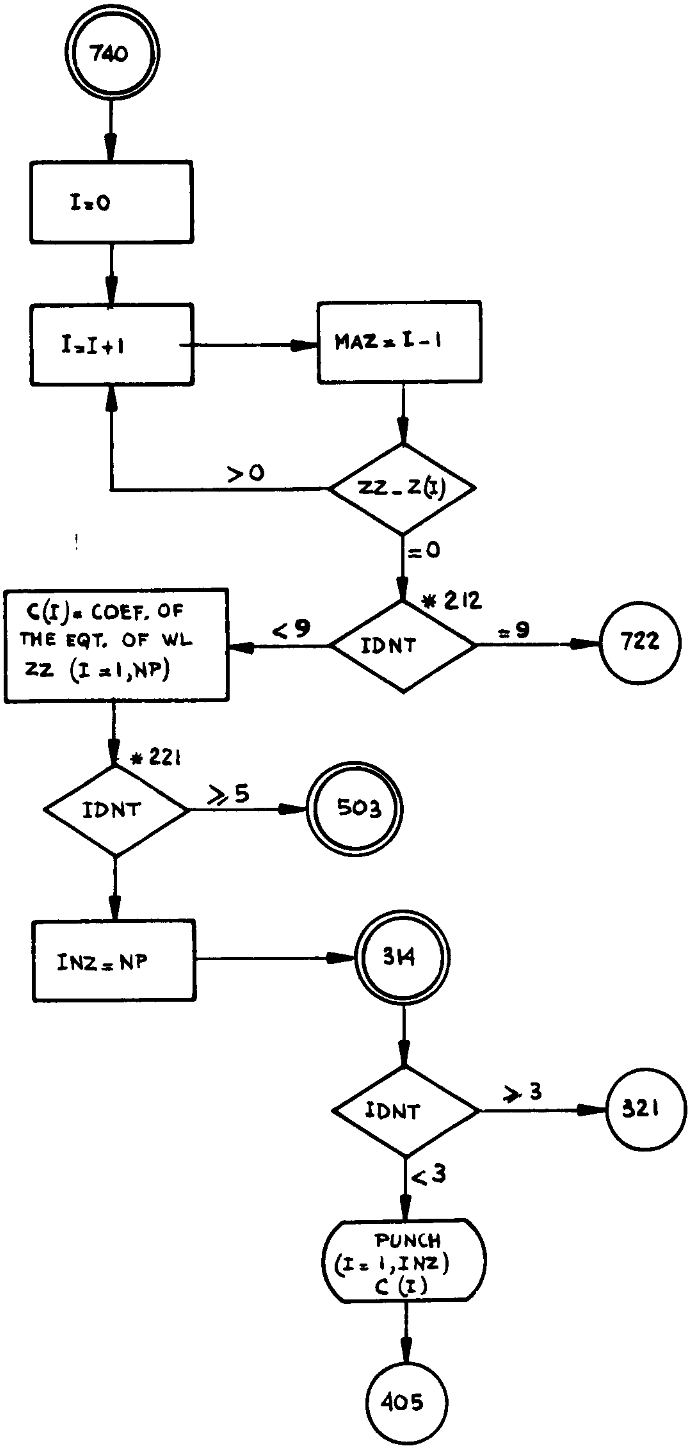
C. FLOW DIAGRAM - GOBACK 1

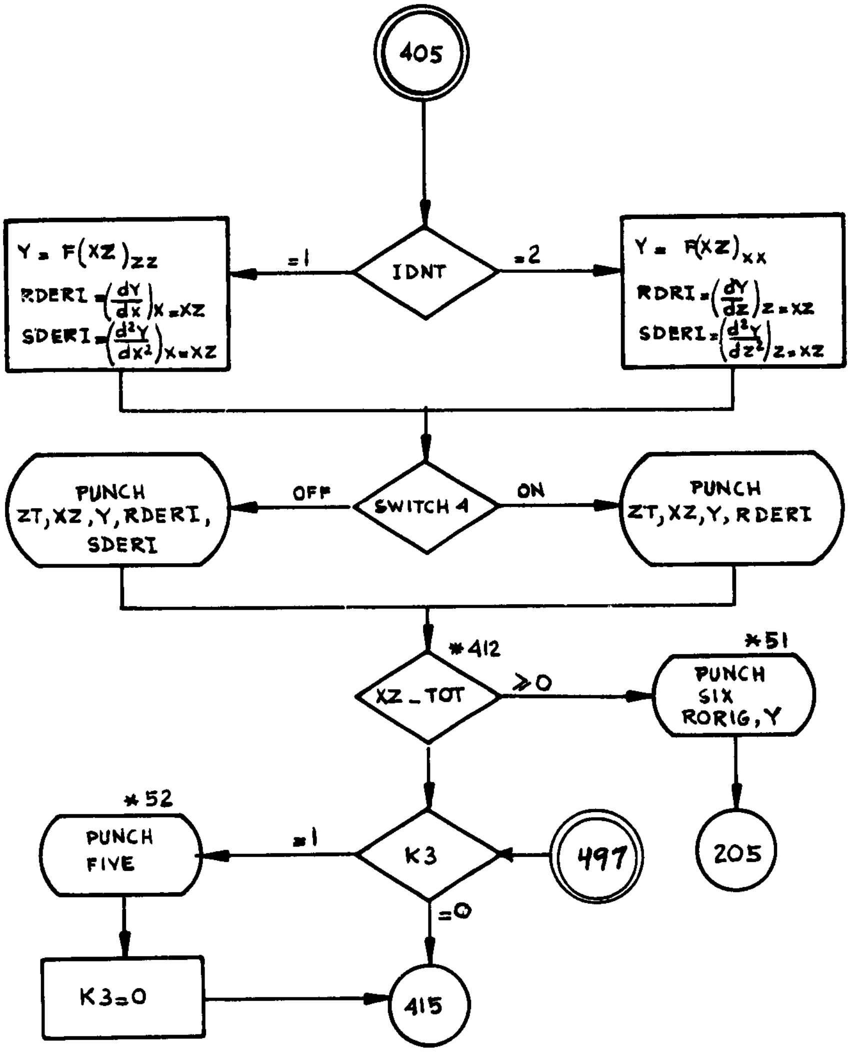


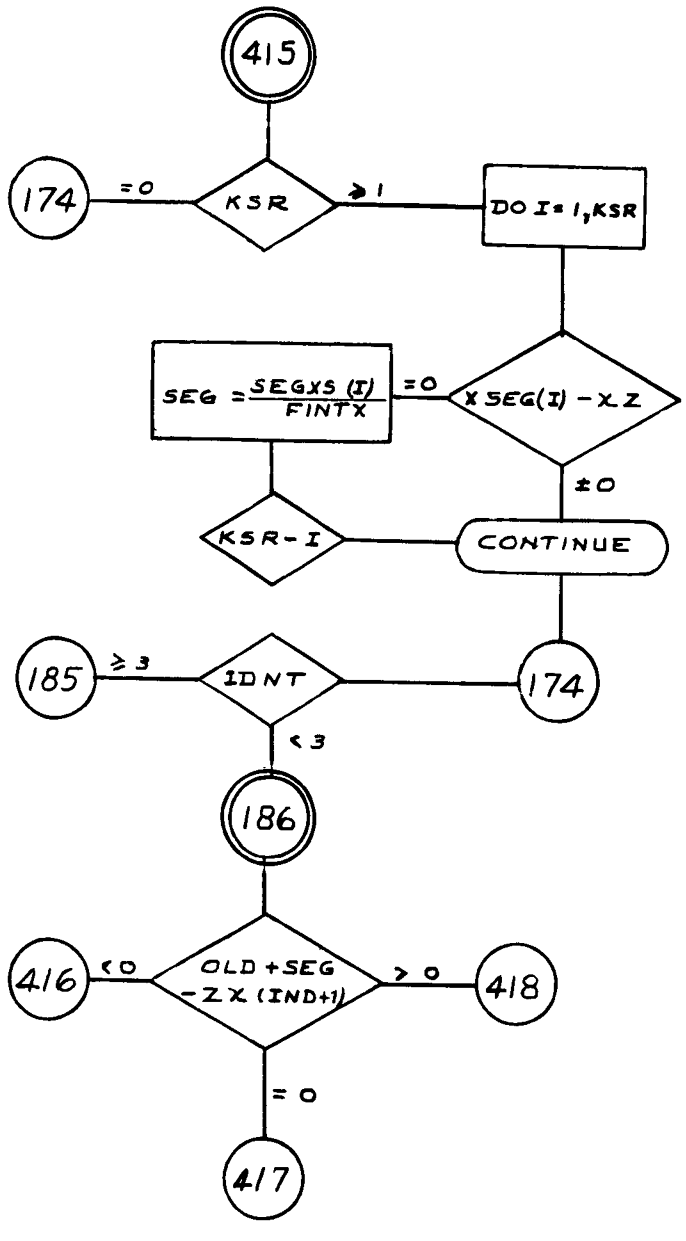

230
READ(I=1,N)
X(I)
TOTX = X (N)
NORMALIZE X (I)
X(I) = X(I) - XORIG / FINTX
WHERE I=1 THRU N
205
READ
IDNT
K2 = 0
K3 = 1
KSR = KS
XZ = 0
KID = 1
IND = 0
OLD = 0
IDNT
= 1
209
600

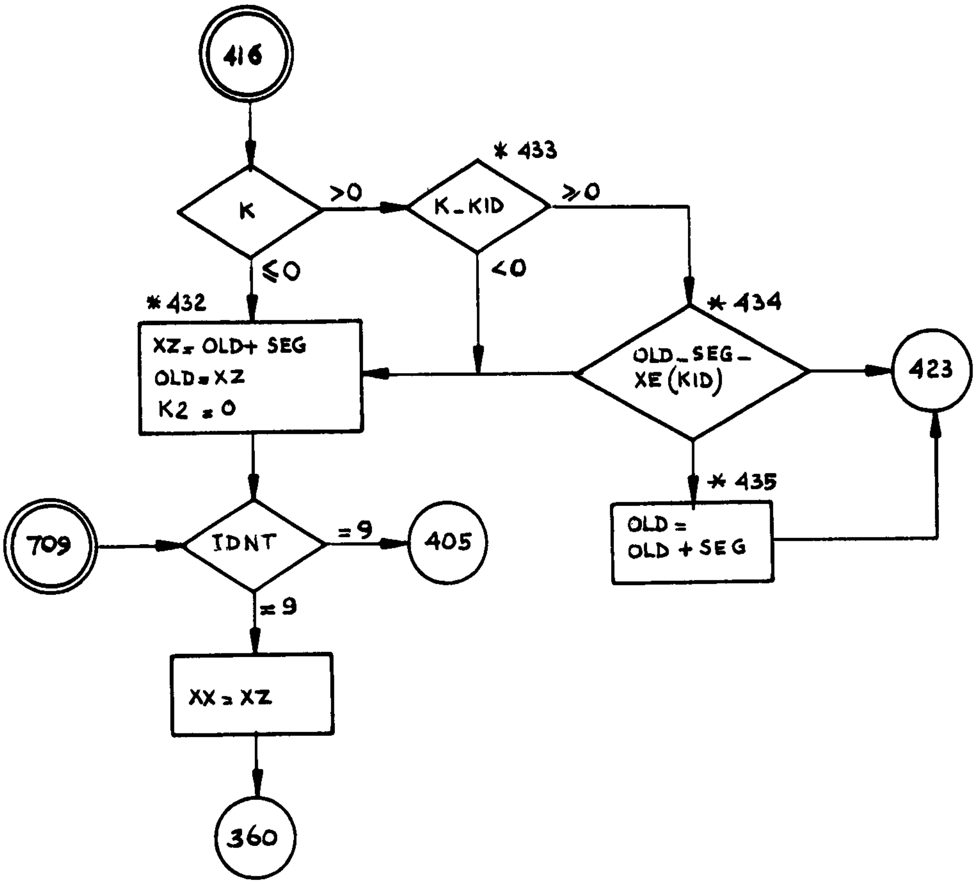

600
IDNT
=2
310
≠2
IDNT
=3
231
≠3
IDNT
=4
234
≠4
IDNT
=5
801
≠5
IDNT
=6
831
≠6
IDNT
=7
800
≠7
IDNT
=8
820
=9
700

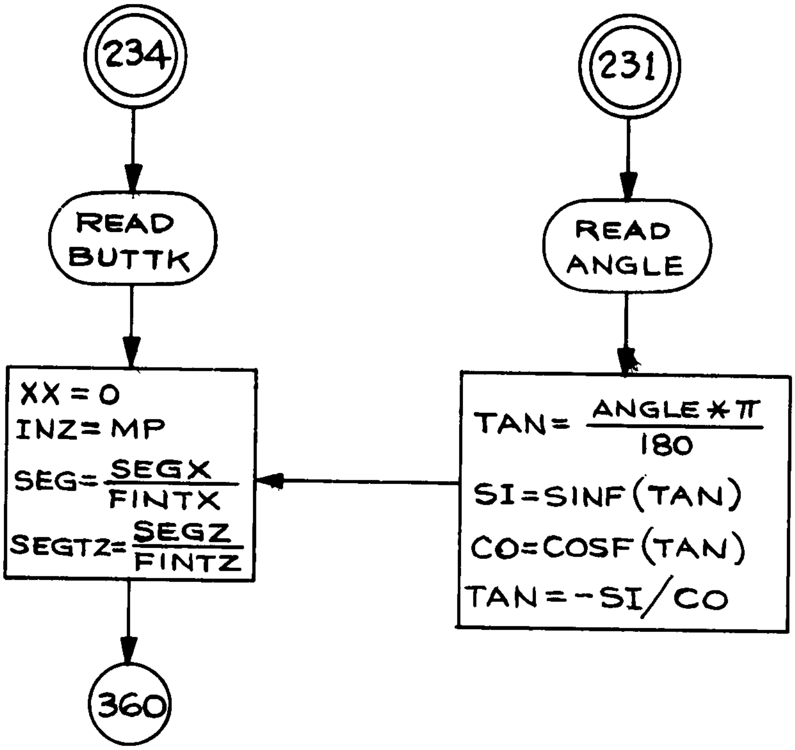

209
READ
K,ZT
K
>0
=0
READ (I=1,K)
ISP(I),XE(I)
* 200
FINT = FINT X
SEG = SEG X / FINT X
RORIG = X ORIG
TOT = TOT X
IK = 0
NORMALIZE XE (I)
XE(I) = XE(I) - XORIG / FINTX
WHERE I = 1 THRU K
801
READ
ZT
NR = N
RORIG = XORIG
FINT = FINTX
804
INX = NP
ZX(I) = X (I)
(I = N, 1)
ZZ = ZT - ZORIG / FINTZ
740

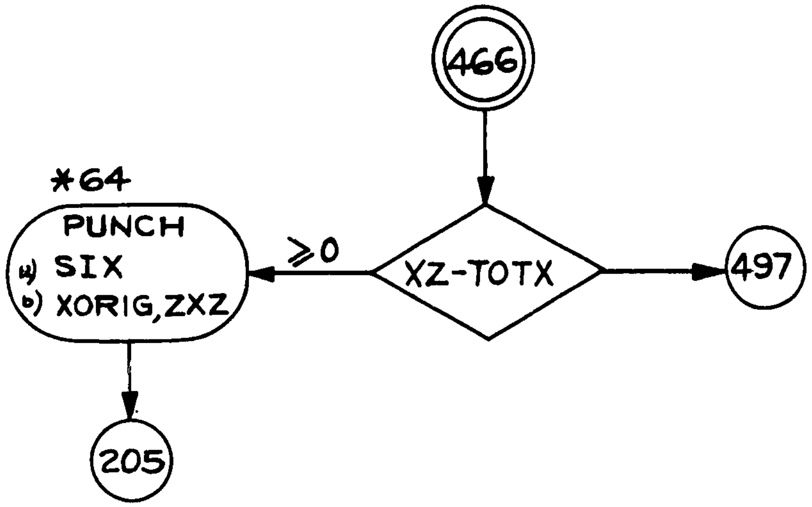

740
I=0
I=I+1
MAZ=I-1
>0
ZZ-Z(I)
=0
*212
C(I)= COEF. OF
THE EQT. OF WL
ZZ (I=1,NP)
<9
IDNT
=9
722
*221
IDNT
≥5
503
INZ=NP
314
IDNT
≥3
321
<3
PUNCH
(I=1,INZ)
C(I)
405

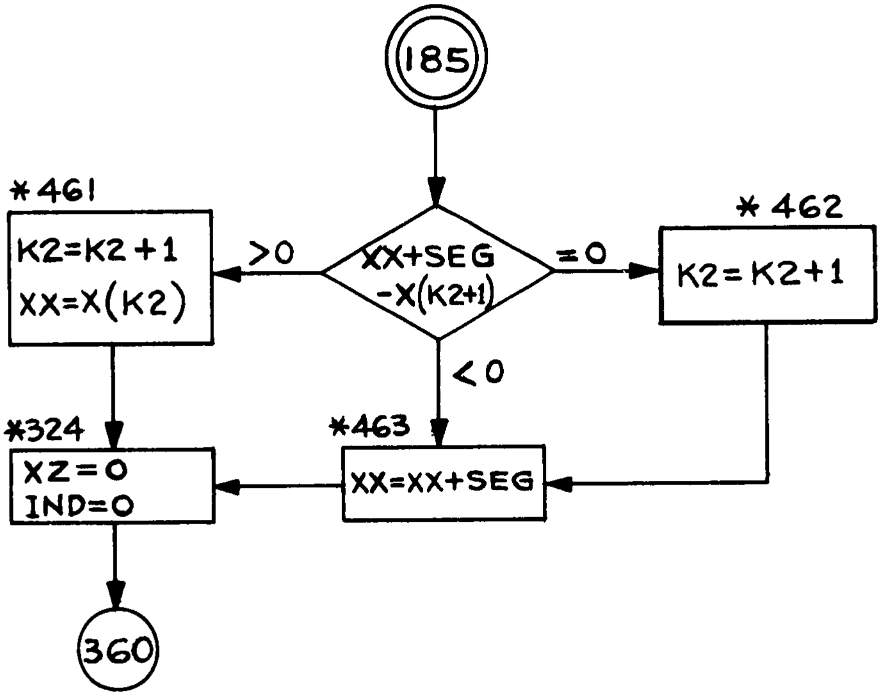

405
IDNT
=1
=2
Y = F(XZ)ZZ
RDERI = (dY/dx)X=XZ
SDERI = (d²Y/dx²)X=XZ
Y = F(XZ)XX
RDRI = (dY/dz)Z=XZ
SDERI = (d²Y/dz²)Z=XZ
SWITCH 4
OFF
ON
PUNCH ZT, XZ, Y, RDERI, SDERI
PUNCH ZT, XZ, Y, RDERI
*412
XZ _ TOT
≥0
*51
PUNCH SIX RORIG, Y
205
K3
=1
=0
497
*52
PUNCH FIVE
K3=0
415

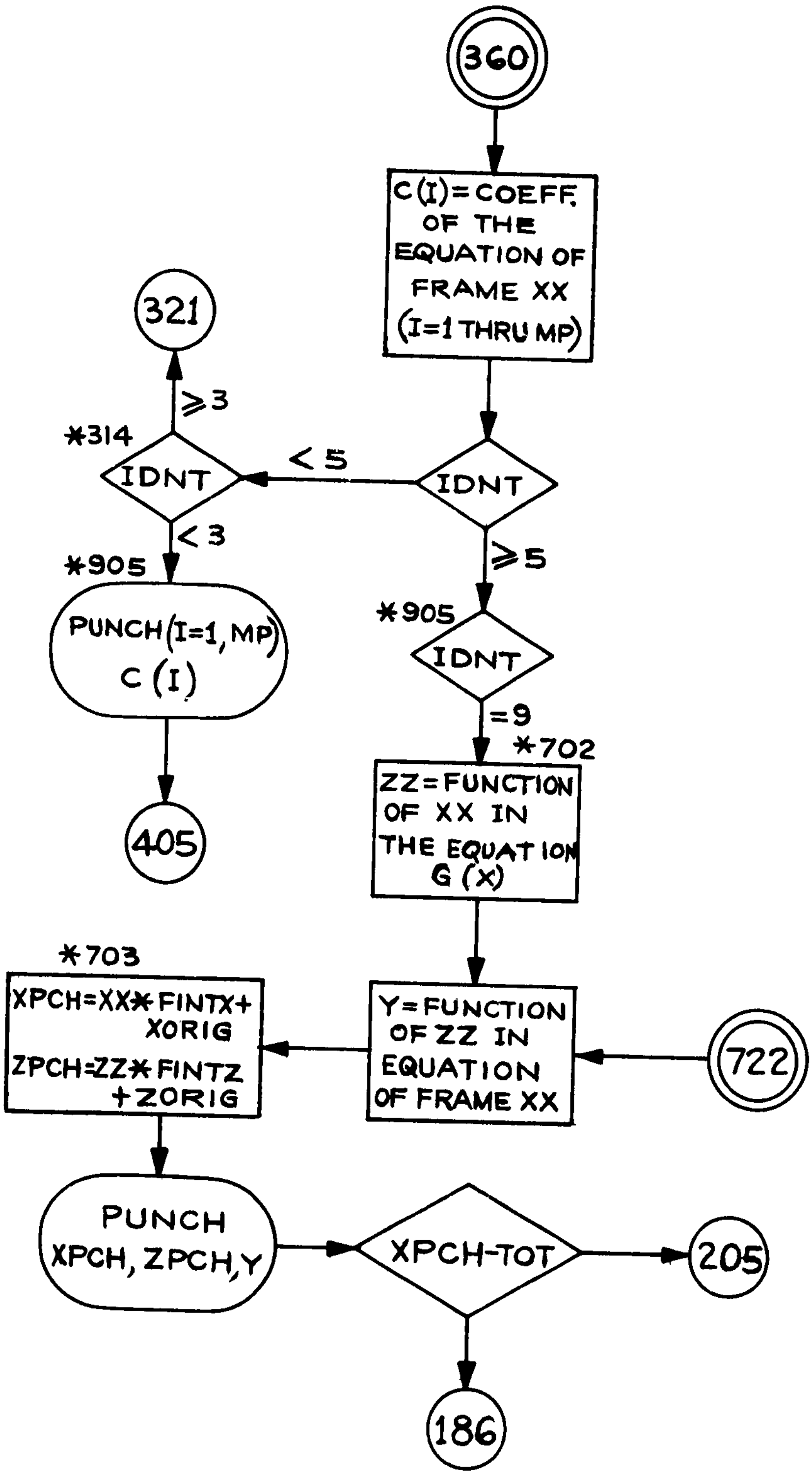

415
174
=0
KSR
≥1
DO I= 1,KSR
SEG = SEGXS (I) / FINTX
=0
XSEG(I) - XZ
≠0
KSR-I
CONTINUE
185
≥ 3
IDNT
174
< 3
186
416
< 0
OLD + SEG - ZX (IND+1)
> 0
418
= 0
417

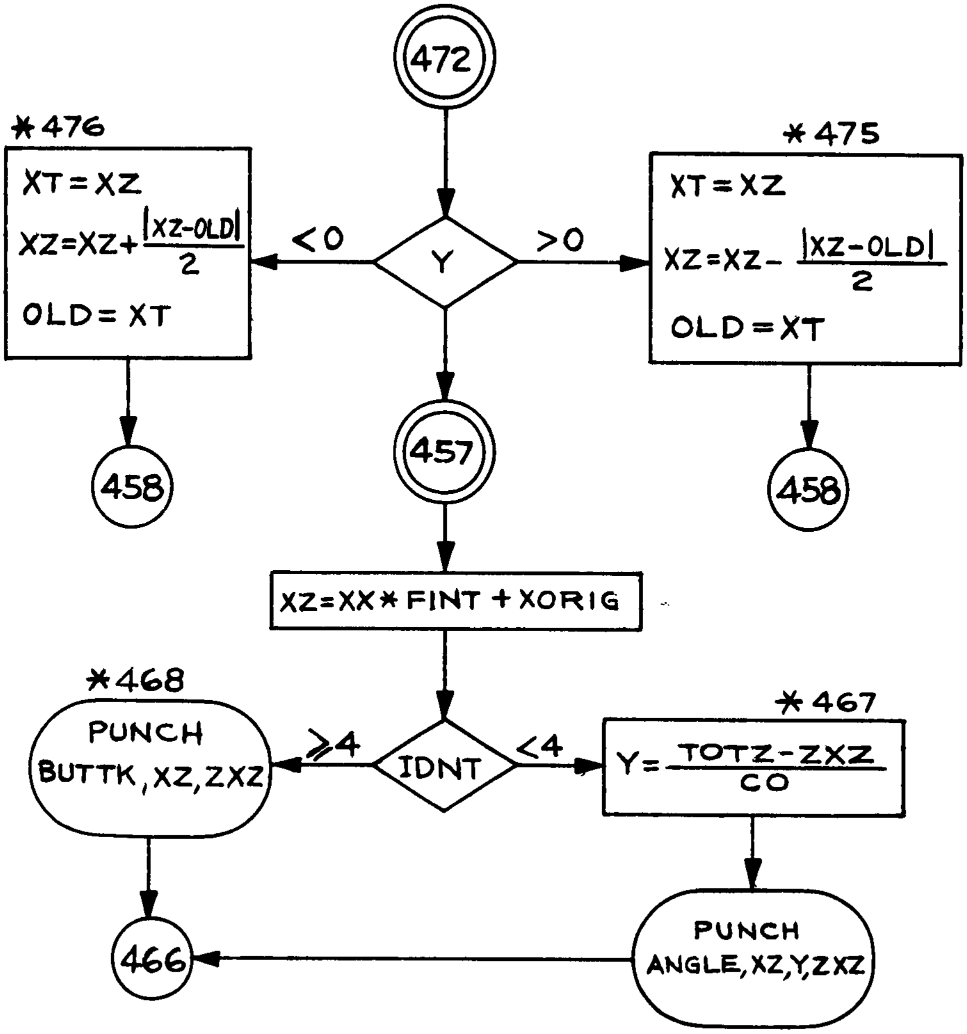

416
K
>0
≤0
* 433
K_KID
≥0
<0
* 432
XZ = OLD+ SEG
OLD = XZ
K2 = 0
* 434
OLD_SEG_
XE (KID)
423
* 435
OLD =
OLD + SEG
709
IDNT
=9
405
≠9
XX = XZ
360

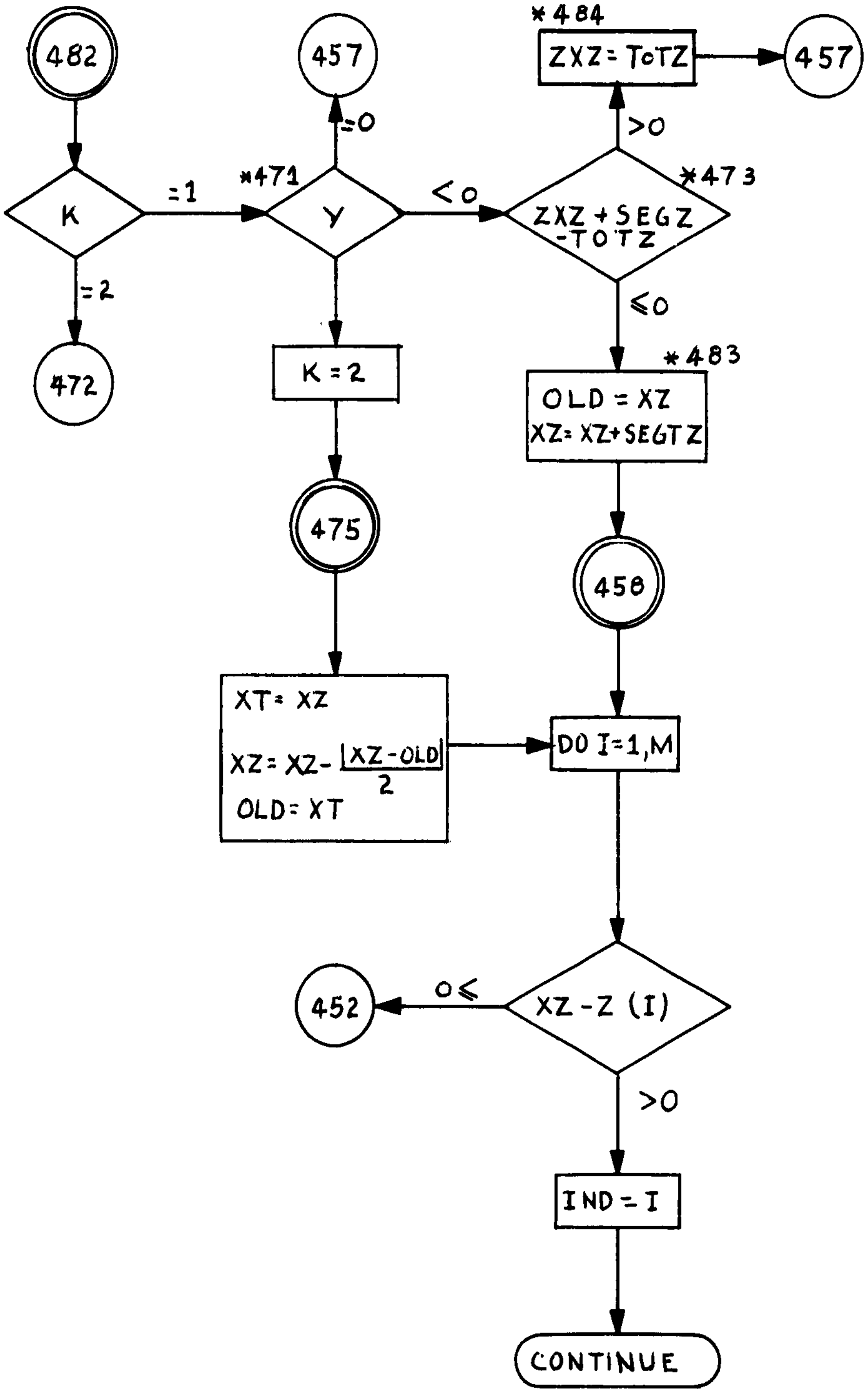

234
READ BUTTK
XX = 0
INZ= MP
SEG= SEGX / FINTX
SEGTZ= SEGZ / FINTZ
360
231
READ ANGLE
TAN= ANGLE * π / 180
SI=SINF(TAN)
CO=COSF(TAN)
TAN=-SI/CO

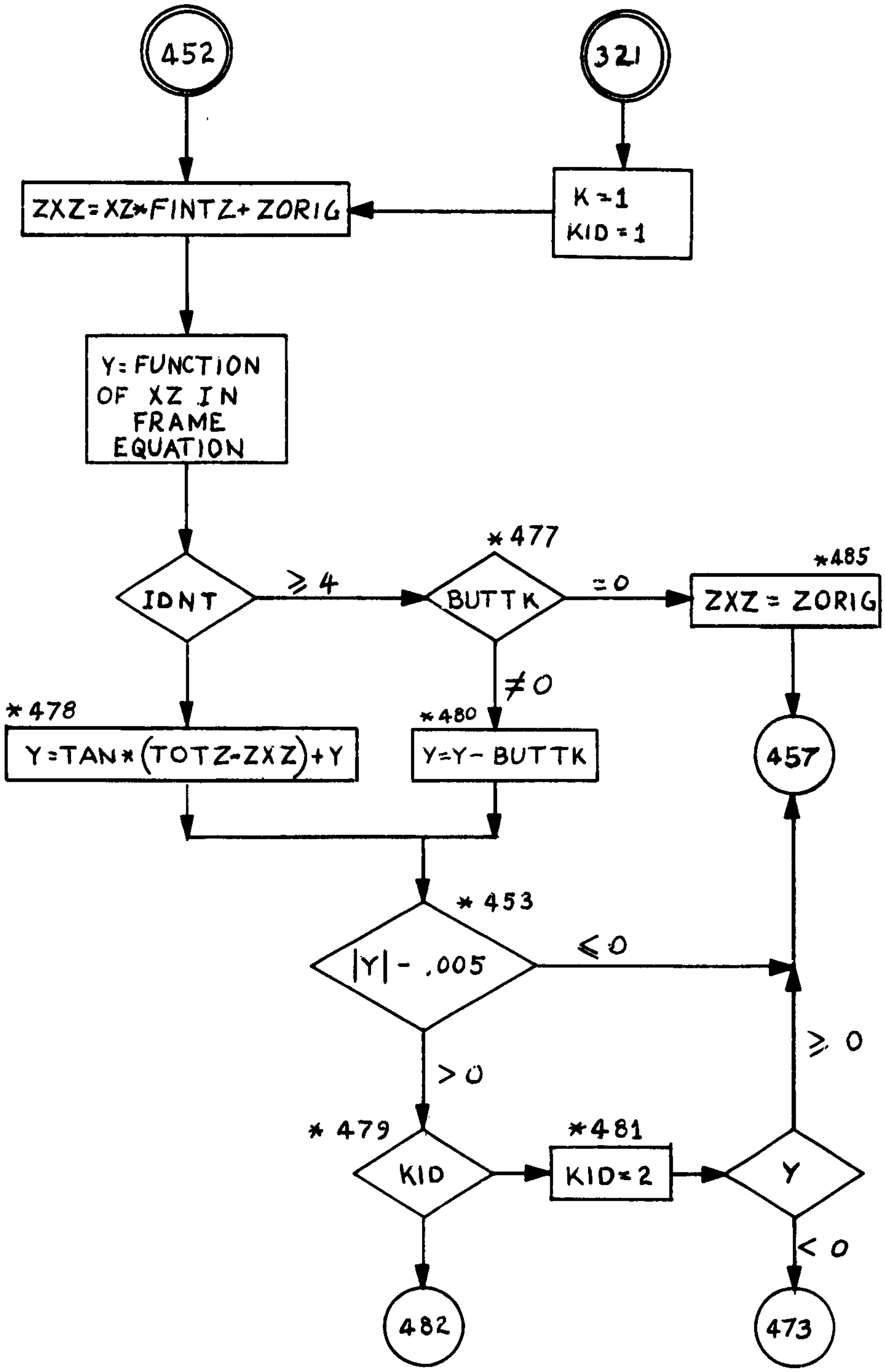

466
*64
PUNCH
a) SIX
b) XORIG,ZXZ
≥0
XZ-TOTX
497
205


185
*461
K2=K2+1
XX=X(K2)
>0
XX+SEG
-X(K2+1)
=0
*462
K2=K2+1
<0
*324
XZ=0
IND=0
*463
XX=XX+SEG
360

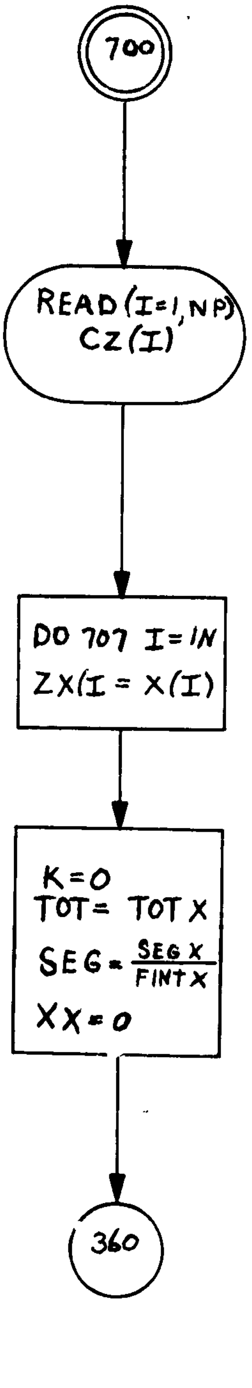

360
C(I)=COEFF.
OF THE
EQUATION OF
FRAME XX
(I=1 THRU MP)
321
≥3
*314
IDNT
<5
IDNT
<3
≥5
*905
PUNCH(I=1, MP)
C (I)
*905
IDNT
=9
*702
405
ZZ=FUNCTION
OF XX IN
THE EQUATION
G (X)
*703
XPCH=XX*FINTX+
XORIG
ZPCH=ZZ*FINTZ
+ZORIG
Y=FUNCTION
OF ZZ IN
EQUATION
OF FRAME XX
722
PUNCH
XPCH, ZPCH, Y
XPCH-TOT
205
186


472
*476
XT = XZ
XZ=XZ+ |XZ-OLD| / 2
OLD = XT
<0
Y
>0
*475
XT = XZ
XZ=XZ- |XZ-OLD| / 2
OLD = XT
458
457
458
XZ=XX*FINT + XORIG
*468
PUNCH
BUTTK, XZ, ZXZ
≥4
IDNT
<4
*467
Y = TOTZ-ZXZ / CO
PUNCH
ANGLE, XZ, Y, ZXZ
466

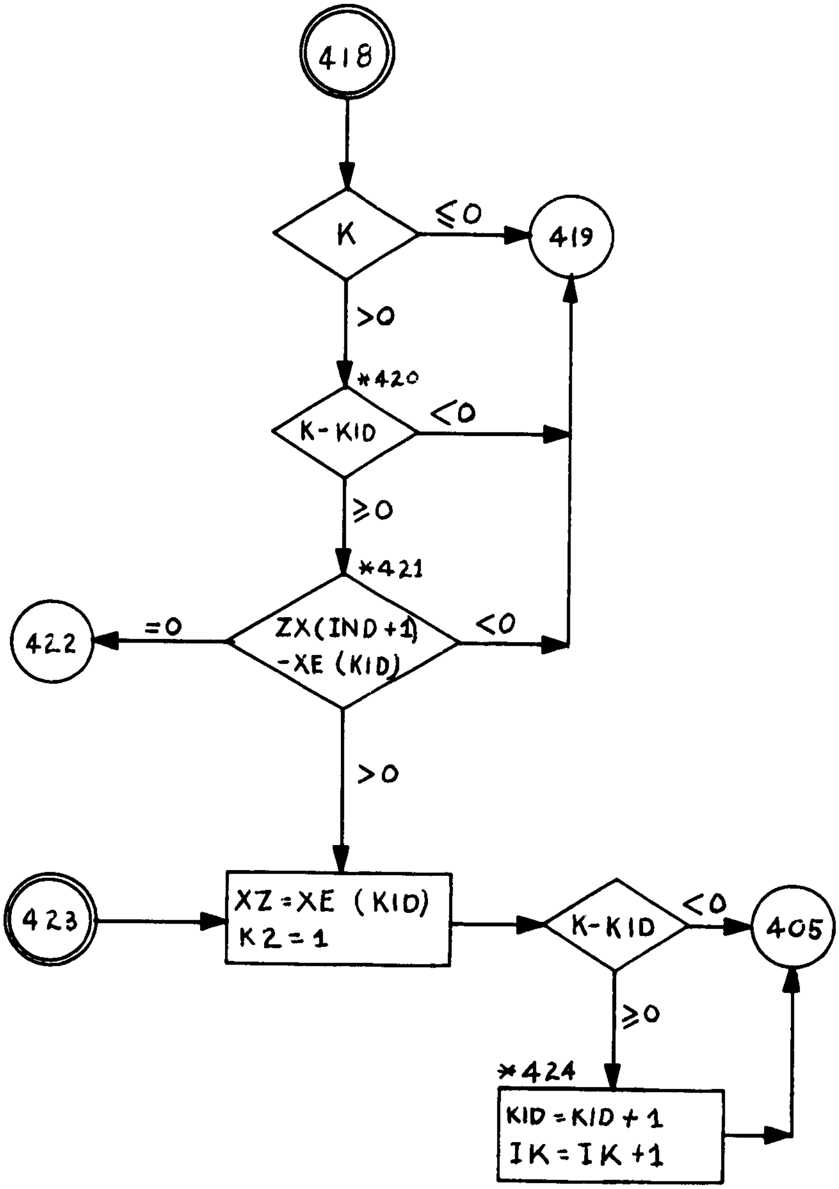

482
K
=1
=2
472
*471
Y
=0
457
<0
K = 2
475
XT = XZ
XZ = XZ - |XZ-OLD| / 2
OLD = XT
*484
ZXZ = TOTZ
457
>0
*473
ZXZ + SEGZ -TOTZ
≤0
*483
OLD = XZ
XZ = XZ+SEGTZ
458
DO I=1,M
XZ - Z (I)
0≤
452
>0
IND = I
CONTINUE

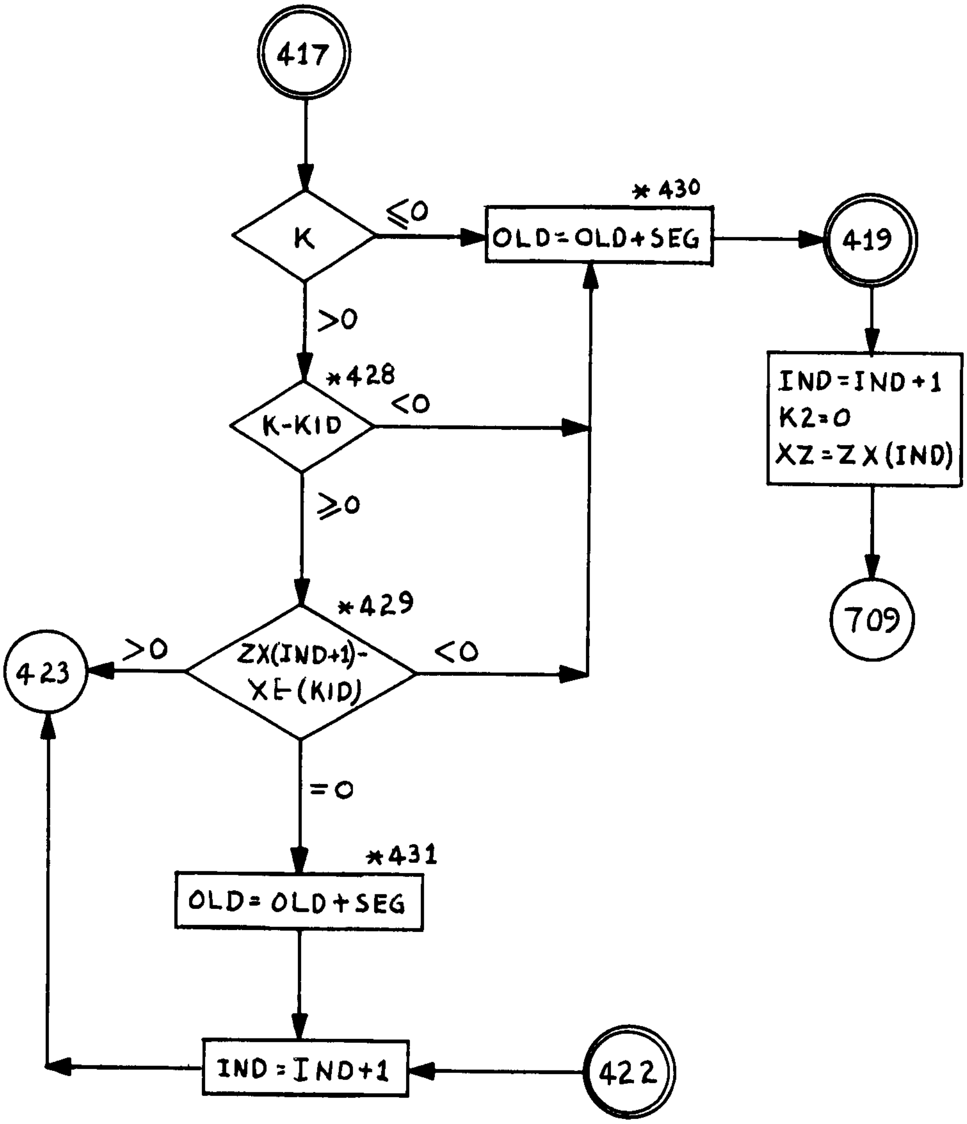


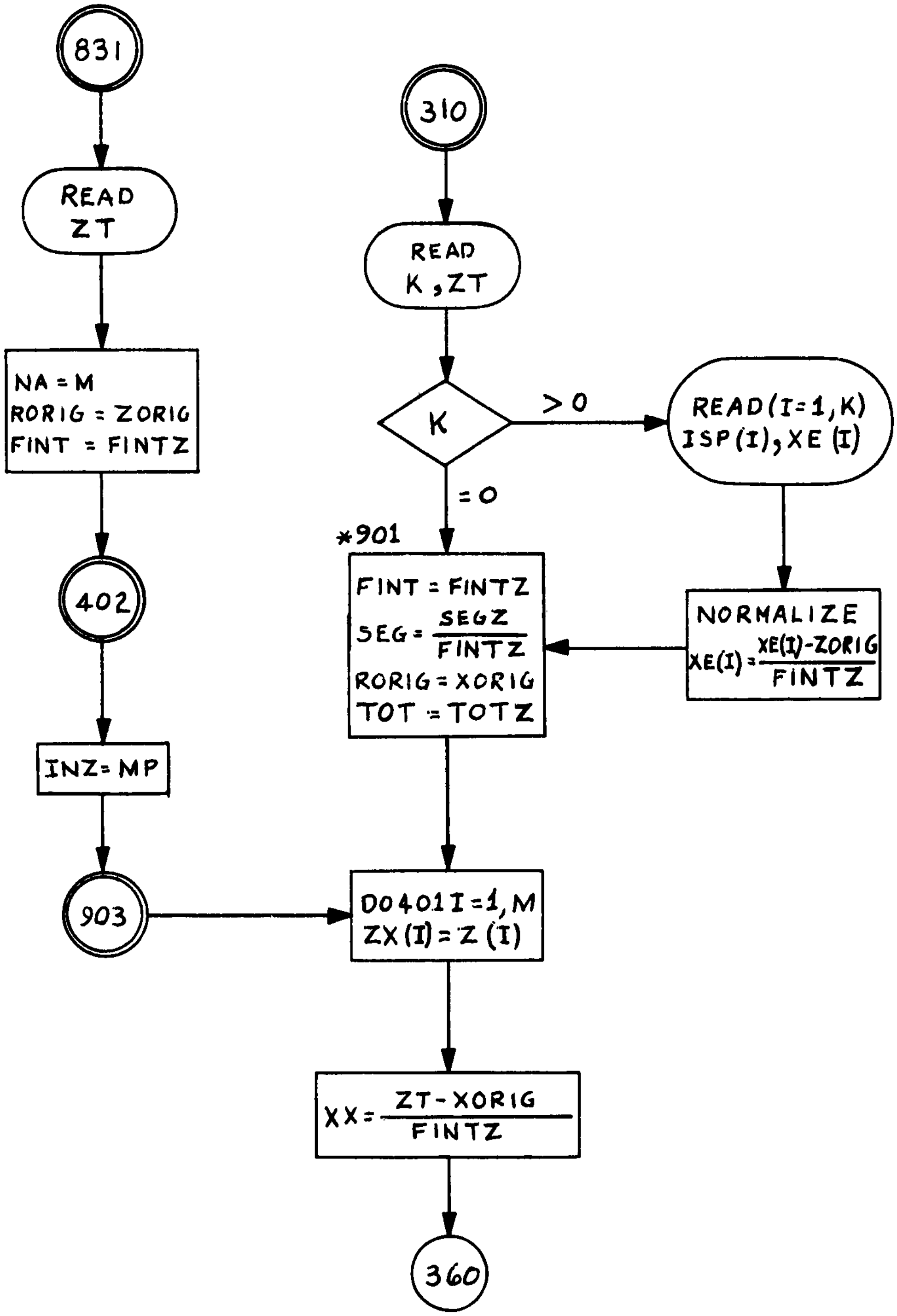
452
321
ZXZ=XZ*FINTZ+ZORIG
K=1
KID=1
Y: FUNCTION OF XZ IN FRAME EQUATION
IDNT
≥4
*477
BUTTK
=0
*485
ZXZ = ZORIG
≠0
*478
Y=TAN*(TOTZ-ZXZ)+Y
*480
Y=Y- BUTTK
457
*453
|Y| - .005
≤0
>0
≥ 0
*479
KID
*481
KID=2
Y
< 0
482
473


700
READ (I=1, NP) CZ(I)
DO 707 I=1N
ZX(I = X(I)
K=0
TOT= TOT X
SEG= SEG X / FINT X
XX=0
360

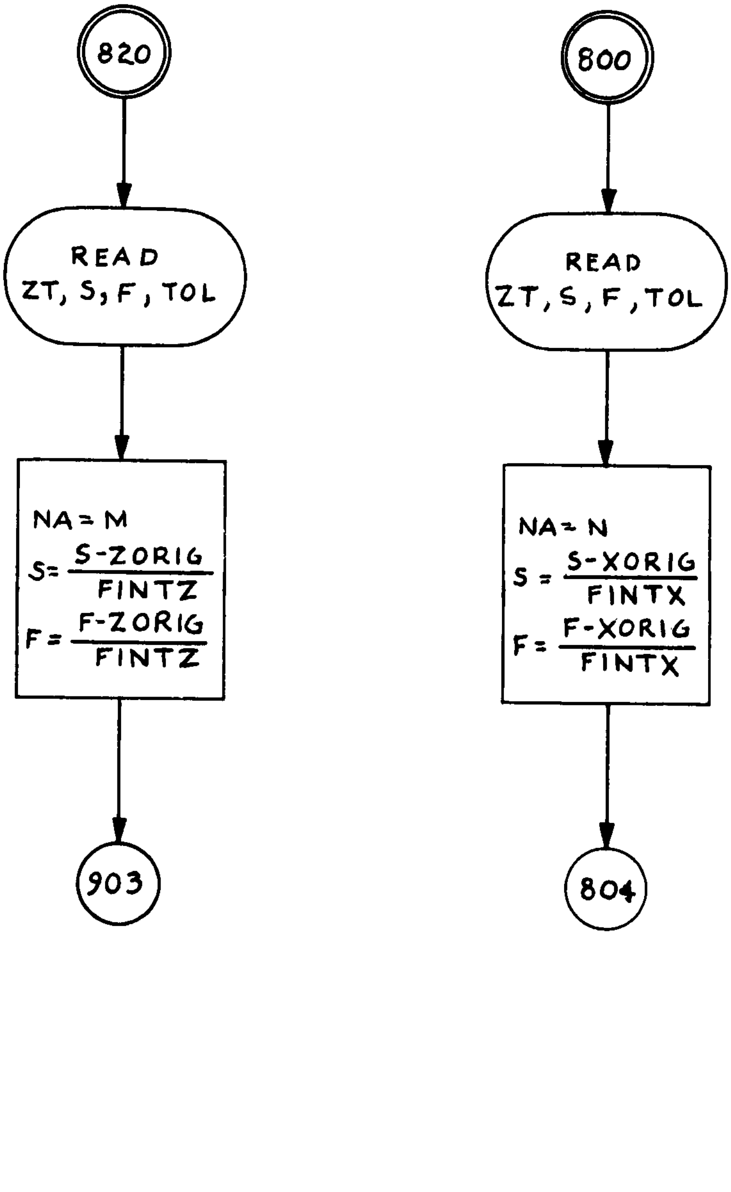
1.0.0-2

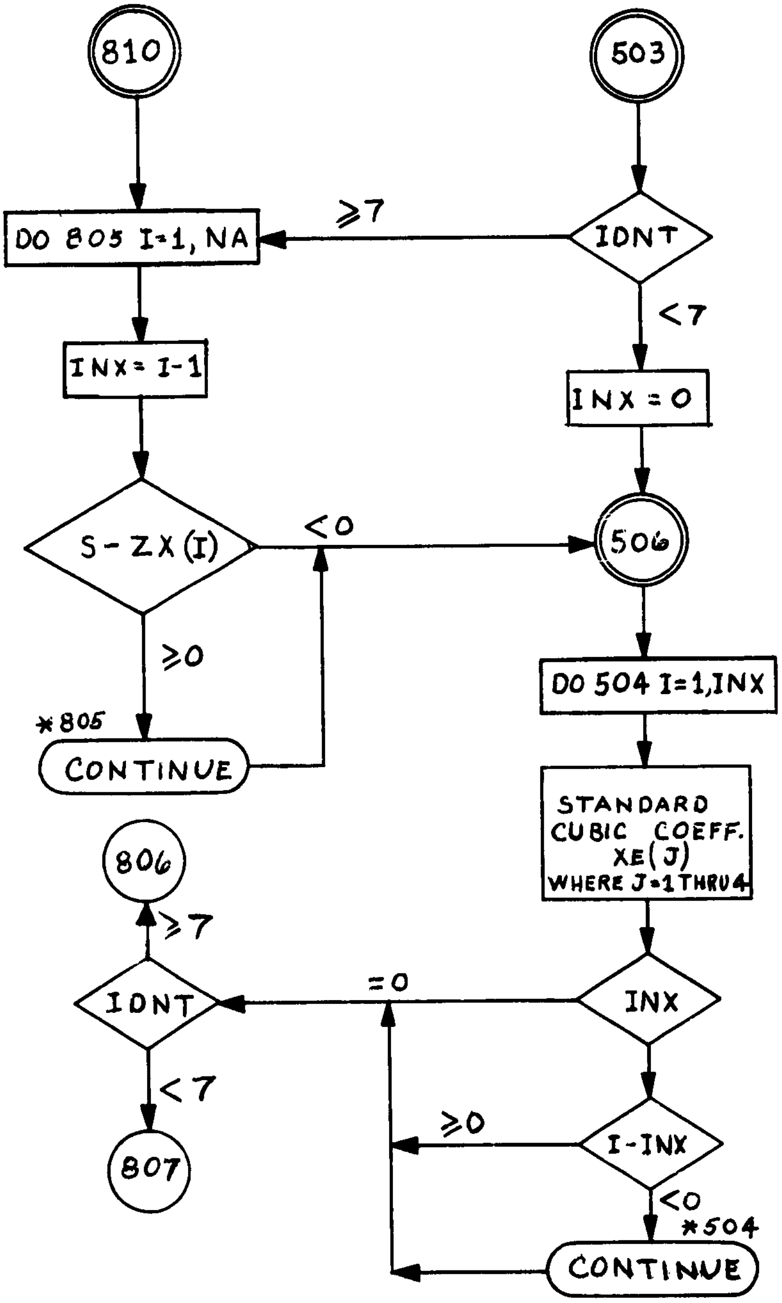

418
K
≤0
419
>0
*420
K-KID
<0
≥0
*421
ZX(IND+1)
-XE (KID)
=0
422
<0
>0
423
XZ=XE (KID)
K2=1
K-KID
<0
405
≥0
*424
KID=KID+1
IK=IK+1

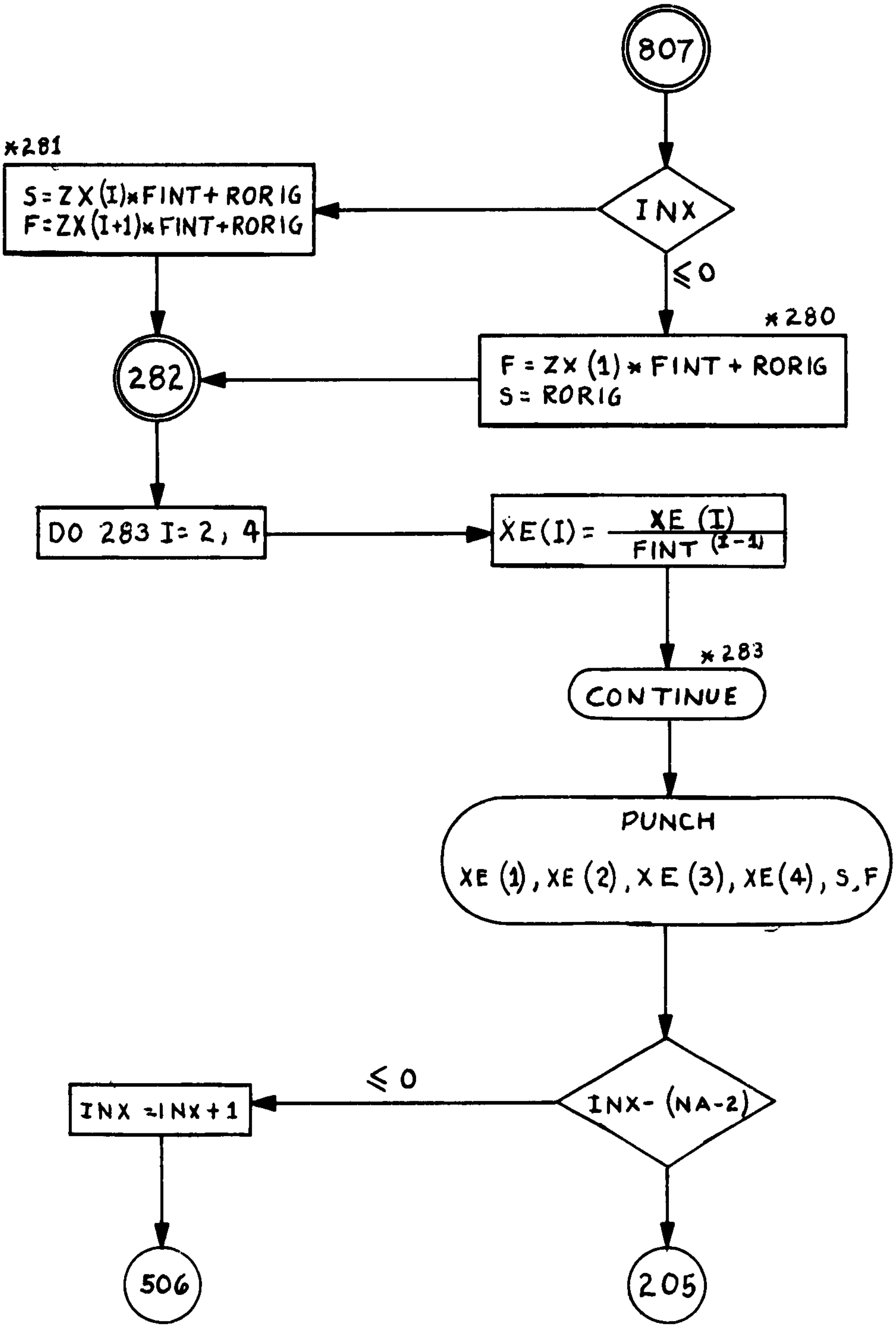

417
K
≤0
>0
*430
OLD=OLD+SEG
419
IND=IND+1
K2=0
XZ=ZX(IND)
709
*428
K-KID
<0
≥0
*429
423
>0
ZX(IND+1)-
XE(KID)
<0
=0
*431
OLD=OLD+SEG
IND=IND+1
422

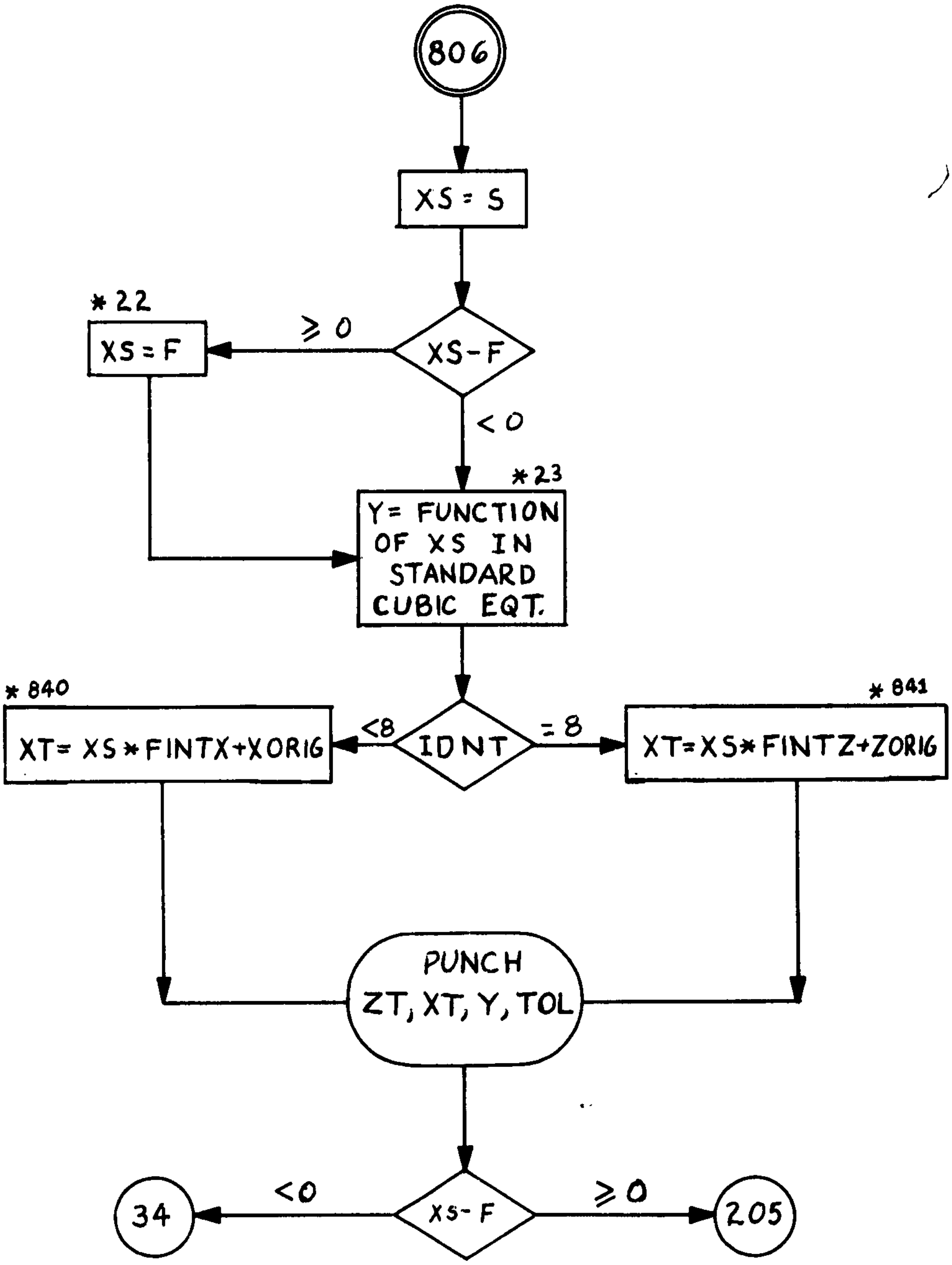


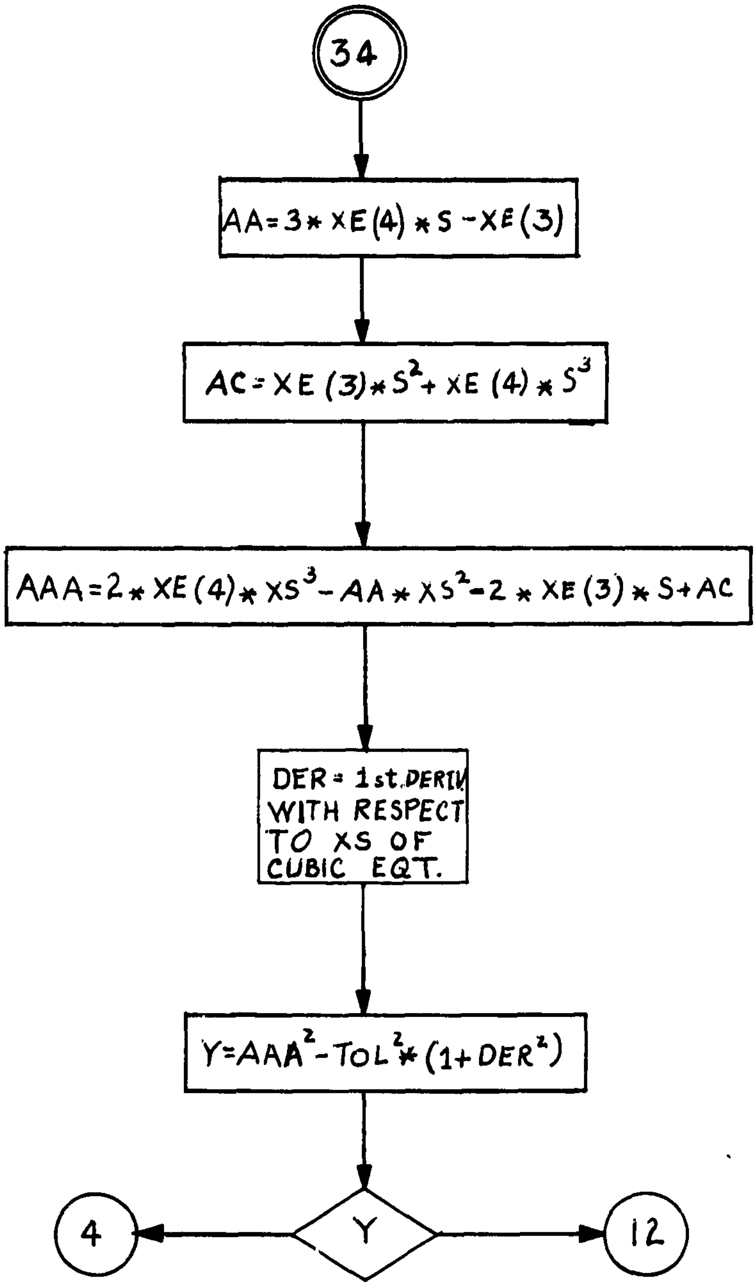
831
READ ZT
NA = M
RORIG = ZORIG
FINT = FINTZ
402
INZ = MP
903
310
READ K, ZT
K
> 0
READ (I = 1, K) ISP (I), XE (I)
NORMALIZE
XE(I) = (XE(I) - ZORIG) / FINTZ
= 0
*901
FINT = FINTZ
SEG = SEGZ / FINTZ
RORIG = XORIG
TOT = TOTZ
DO 401 I = 1, M
ZX (I) = Z (I)
XX = (ZT - XORIG) / FINTZ
360

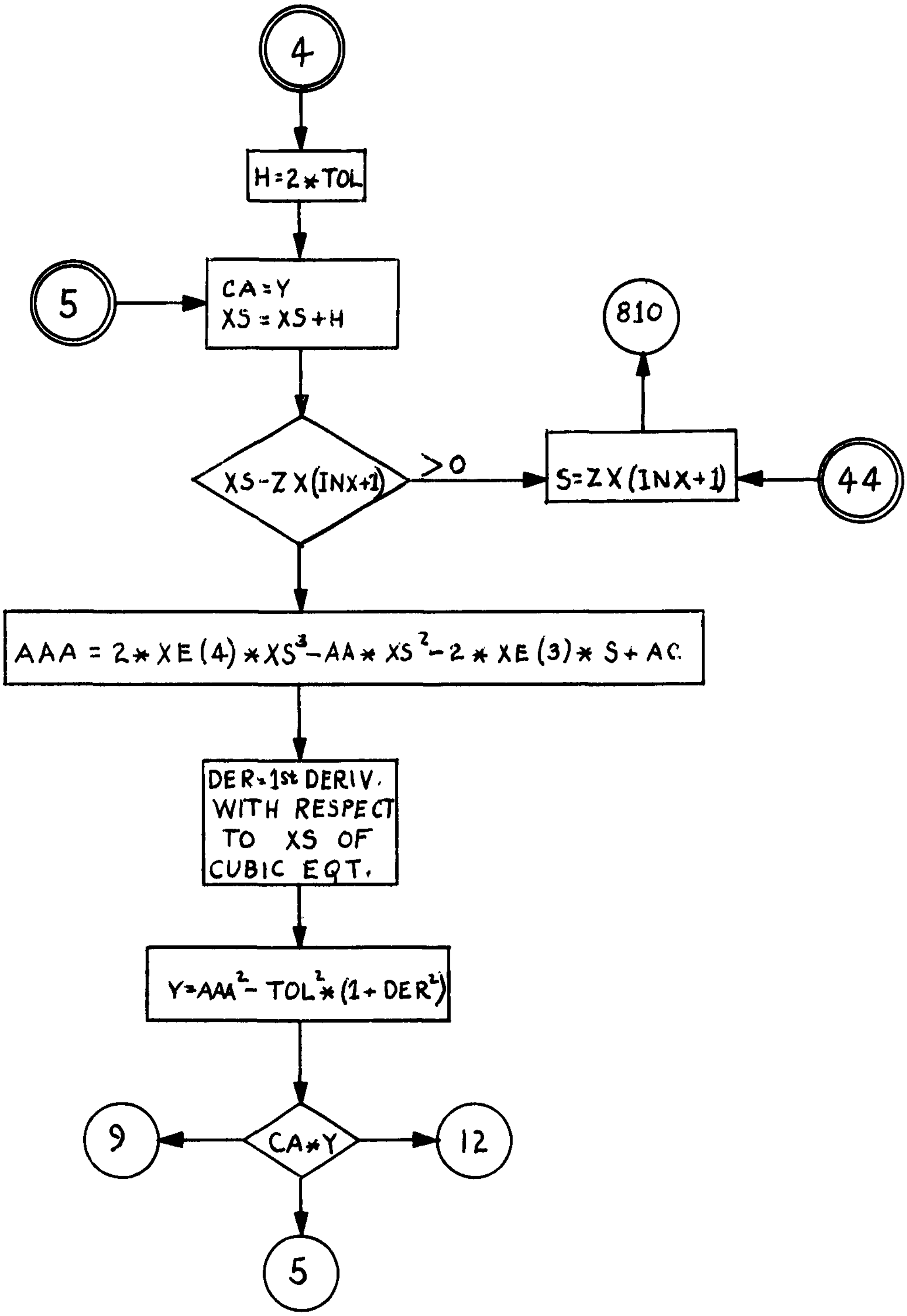

820
READ
ZT, S, F, TOL
NA = M
S = S-ZORIG / FINTZ
F = F-ZORIG / FINTZ
903
800
READ
ZT, S, F, TOL
NA = N
S = S-XORIG / FINTX
F = F-XORIG / FINTX
804

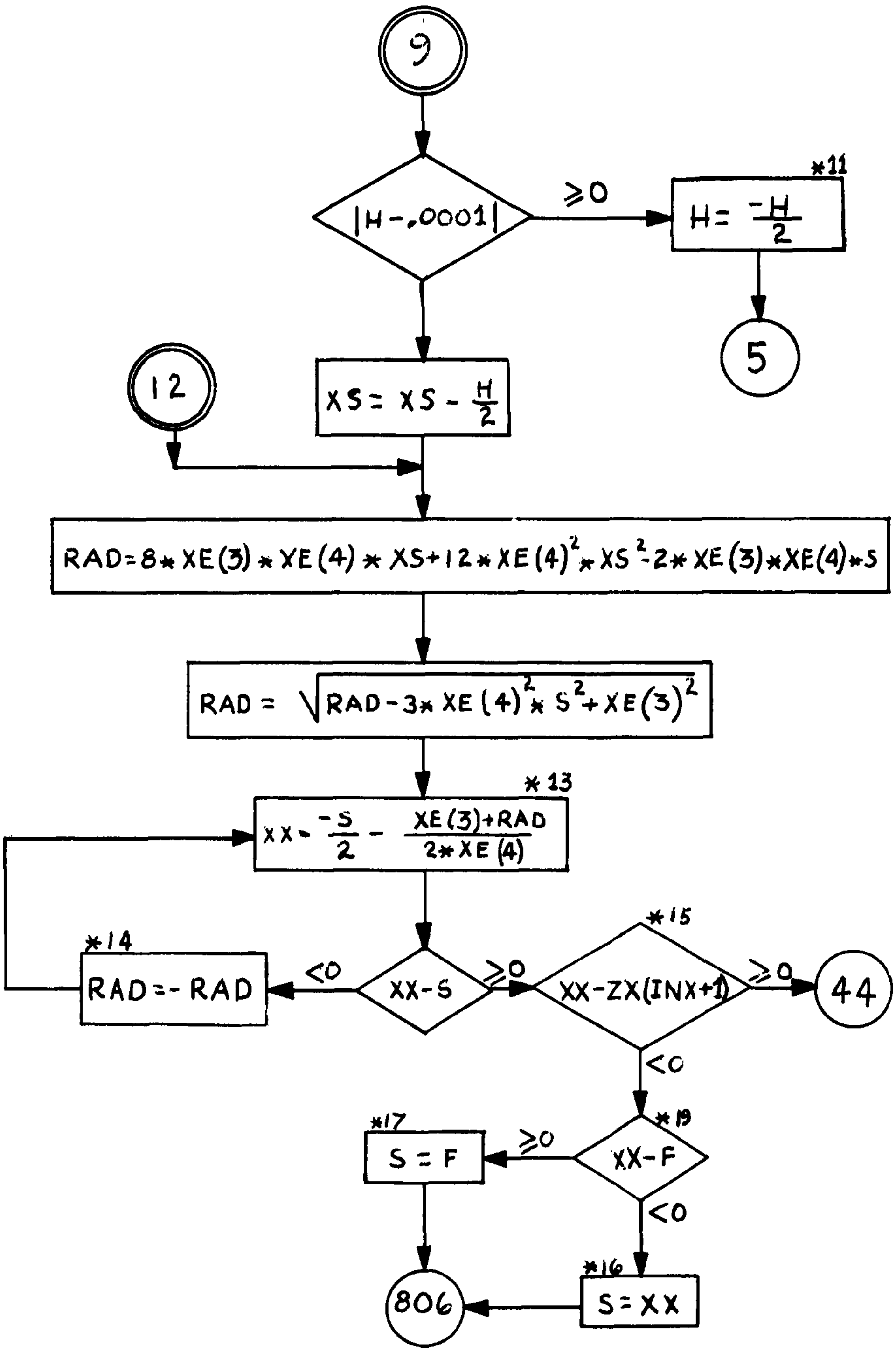

810
503
DO 805 I=1, NA
≥7
IDNT
<7
INX= I-1
INX = 0
S - ZX (I)
<0
506
≥0
DO 504 I=1,INX
*805
CONTINUE
STANDARD
CUBIC COEFF.
XE(J)
WHERE J=1 THRU 4
806
≥7
IDNT
=0
INX
<7
≥0
I-INX
807
<0
*504
CONTINUE


807
INX
*281
S=ZX(I)*FINT+RORIG
F=ZX(I+1)*FINT+RORIG
≤0
*280
F = ZX (1) * FINT + RORIG
S = RORIG
282
DO 283 I= 2, 4
XE(I) = XE (I) / FINT (I-1)
*283
CONTINUE
PUNCH
XE (1), XE (2), X E (3), XE(4), S, F
≤ 0
INX =INX+1
INX- (NA-2)
506
205


806
XS = S
*22
XS = F
≥ 0
XS-F
< 0
*23
Y= FUNCTION OF XS IN STANDARD CUBIC EQT.
*840
XT= XS*FINTX+XORIG
<8
IDNT
= 8
*841
XT=XS*FINTZ+ZORIG
PUNCH ZT, XT, Y, TOL
34
<0
XS- F
≥ 0
205


34
AA=3*XE(4)*S-XE(3)
AC=XE(3)*S^2+XE(4)*S^3
AAA=2*XE(4)*XS^3-AA*XS^2-2*XE(3)*S+AC
DER = 1st.DERIV WITH RESPECT TO XS OF CUBIC EQT.
Y=AAA^2-TOL^2*(1+DER^2)
Y
4
12


4
H=2*TOL
5
CA=Y
XS=XS+H
810
XS-ZX(INX+1)
>0
S=ZX(INX+1)
44
AAA = 2*XE(4)*XS³-AA*XS²-2*XE(3)*S+AC
DER=1st DERIV. WITH RESPECT TO XS OF CUBIC EQT.
Y=AAA²-TOL²*(1+DER²)
9
CA*Y
12
5


9
|H-.0001|
≥0
*11
H= -H/2
5
12
XS = XS - H/2
RAD=8*XE(3)*XE(4)*XS+12*XE(4)^2*XS^2-2*XE(3)*XE(4)*S
RAD = √(RAD-3*XE(4)^2*S^2+XE(3)^2)
*13
XX = -S/2 - (XE(3)+RAD)/(2*XE(4))
*14
RAD=-RAD
<0
XX-S
≥0
*15
XX-ZX(INX+1)
≥0
44
<0
*17
S = F
≥0
*19
XX-F
<0
*16
S=XX
806

D. LISTING - GOBACK 1

```
C      SURFACE GO BACK  (NO PROFILE)
  101 FORMAT(4F15.8,2I5)
  102 FORMAT(4F15.8)
  103 FORMAT(5HGO TO,4X,F14.8,3X,F15.8)
  104 FORMAT(2F15.8,I5)
  105 FORMAT(7H IDENT.,9X,1HZ,17X,1HY,11X,10HFIRST DER.,4X,11HSECOND
DER
     C.)
  106 FORMAT(I4,F15.8)
  107 FORMAT(2HWL,F7.2,F14.8,3X,3F15.8)
  108 FORMAT(8HPEN DOWN,F15.8)
  109 FORMAT(2HFR,F7.2,F14.8,3X,3F15.8)
  110 FORMAT(6HPEN UP,2X,F15.8)
  111 FORMAT(2HLG,I3,3X,F15.8,3X,F15.8)
  112 FORMAT(7H IDENT.,9X,1HZ,17X,1HY,12X,9HTOLERANCE)
  113 FORMAT(7H IDENT.,9X,1HX,17X,1HY,12X,9HTOLERANCE)
  114 FORMAT(2HDP,F6.2,F15.8,3X,2F15.8)
  115 FORMAT(7H IDENT.,9X,1HX,17X,1HY,11X,10HFIRST DER.,4X,11HSECOND
DER
     C.)
  116 FORMAT(1X,6HIDENT.,9X,1HX,17X,1HY,7X,14HFIRST DERIVAT.)
  117 FORMAT(1X,6HIDENT.,10X,1HX,17X,1HY,14X,1HZ)
  118 FORMAT(1X,6HIDENT.,9X,1HZ,17X,1HY,7X,14HFIRST DERIVAT.)
  119 FORMAT(2HBK,F6.2,F15.8,3X,F15.8)
  120 FORMAT(7X,1HA,13X,1HB,13X,1HC,13X,1HD,9X,5HSTART,8H  FINISH)
  121 FORMAT(7H IDENT.,10X,1HX,17X,1HZ)
  122 FORMAT(4F14.8,2F8.3)
  123 FORMAT(50H                                                  )
  124 FORMAT(25H                         )
  125 FORMAT(8X,1HX,14X,1HZ,14X,1HY)
      DIMENSION X(40),A(22,42),XE(40),Z(20),C(43),ZX(40),ISP(20)
      DIMENSION SEGXS(5),XSEG(5),CZ(42)
  100 READ 123
      PUNCH 123
      READ 101,XORIG,ZORIG,FINTX,FINTZ,M,N
      READ 104,SEGX,SEGZ,KS
      IF(KS-1)170,171,172
  171 READ 102,SEGXS(1),XSEG(1)
      GO TO 170
  172 DO 173 I=1,KS
  173 READ 102,SEGXS(I),XSEG(I)
  170 NP=N+2
      MP=M+2
      FIVE=5000.
      SIX=6000.
      DO 201 I=1,MP
      DO 202 J=1,NP
  202 READ 102, A(I,J)
```

```
  201 CONTINUE
      M=MP-3
      N=NP-3
      DO 203 I=1,M
      READ 102,Z(I)
      IF(M-I)230,232,203
  232 TOTZ=Z(I)
  203 Z(I)=(Z(I)-ZORIG)/FINTZ
  230 DO 204 I=1,N
      READ 102,X(I)
      IF(N-I)205,233,204
  233 TOTX=X(I)
  204 X(I)=(X(I)-XORIG)/FINTX
  205 READ 106,IDNT
      K2=0
      K3=1
      KSR=KS
      XZ=0.
      KID=1
      IND=0
      OLD=0.
      IF(IDNT-1)600,209,600
  600 IF(IDNT-2)601,310,601
  601 IF(IDNT-3)602,231,602
  602 IF(IDNT-4)603,234,603
  603 IF(IDNT-5)604,801,604
  604 IF(IDNT-6)605,831,605
  605 IF(IDNT-7)606,800,606
  606 IF(IDNT-8)700,820,700
C     * * A) OFFSETS OF A WATER LINE * *
  209 READ   106,K,ZT
      IF(K-1)200,206,207
  207 DO 210 I=1,K
      READ 111,ISP(I),XE(I)
  210 XE(I)=(XE(I)-XORIG)/FINTX
      GO TO 200
  206 READ 111,ISP(1),XE(1)
      XE(1)=(XE(1)-XORIG)/FINTX
  200 FINT=FINTX
      SEG=SEGX/FINTX
      RORIG=XORIG
      TOT=TOTX
      IK=0
  804 INX=NP
      DO 236 I=1,N
  236 ZX(I)=X(I)
      ZZ=(ZT-ZORIG)/FINTZ
  740 DO 211 I=1,M
```

```
      MAZ=I-1
      IF(ZZ-Z(I))212,212,211
  211 CONTINUE
  212 IF(IDNT-9)721,722,721
  721 DO 213 I=1,INX
  213 C(I)=A(1,I)+A(2,I)*ZZ+A(3,I)*ZZ*ZZ+A(4,I)*ZZ**3
      IF(MAZ-1)221,215,216
  215 DO 217 I=1,INX
  217 C(I)=C(I)+A(5,I)*(ZZ-Z(1))**3
  221 IF(IDNT-5)214,503,503
  216 INZ=MAZ+4
      DO 218 I=1,INX
      DO 219 J=5,INZ
  219 C(I)=C(I)+A(J,I)*(ZZ-Z(J-4))**3
  218 CONTINUE
      IF(IDNT-5)214,503,503
  214 INZ=INX
      GO TO 314
C     * * B) OFFSETS OF A FRAME OR STATION * *
  310 IK=0
      READ 106,K,ZT
      IF(K-1)901,403,404
  403 READ 111,ISP(1),XE(1)
      XE(1)=(XE(1)-ZORIG)/FINTZ
      GO TO 901
  404 DO 400 I=1,K
      READ 111,ISP(I),XE(I)
  400 XE(I)=(XE(I)-ZORIG)/FINTZ
  901 FINT=FINTZ
      SEG=SEGZ/FINTZ
      RORIG=ZORIG
      TOT=TOTZ
  903 DO 401 I=1,M
  401 ZX(I)=Z(I)
      XX=(ZT-XORIG)/FINTX
  360 DO 311 I=1,N
      MAX=I-1
      IF(XX-X(I))312,312,311
  311 CONTINUE
  312 INZ=MP
      DO 313 I=1,INZ
  313 C(I)=A(I,1)+A(I,2)*XX+A(I,3)*XX*XX+A(I,4)*XX**3
      IF(MAX-1)902,315,316
  315 DO 317 I=1,INZ
  317 C(I)=C(I)+A(I,5)*(XX-X(1))**3
  902 IF(IDNT-5)314,906,906
  906 IF(IDNT-9)503,702,503
  316 INX=MAX+4
      DO 318 I=1,INZ
```

```
      DO 319 J=5,INX
  319 C(I)=C(I)+A(I,J)*(XX-X(J-4))**3
  318 CONTINUE
      IF(IDNT-5)314,906,906
  314 IF(IDNT-3)905,321,321
  905 DO 320 I=1,INZ
  320 PUNCH 102,C(I)
      IF(SENSE SWITCH 4)322,323
  322 IF(IDNT-2)181,182,182
  181 PUNCH 116
      GO TO 405
  182 PUNCH 118
      GO TO 405
  323 IF(IDNT-2)183,184,184
  183 PUNCH 115
      GO TO 405
  184 PUNCH 105
  405 Y=C(1)+C(2)*XZ+C(3)*XZ*XZ+C(4)*XZ**3
      TDERI=C(2)+C(3)*2.*XZ+C(4)*3.*XZ*XZ
      SDERI=C(3)*2.+C(4)*6.*XZ
      IF(IND-1)406,408,408
  408 DO 409 I=1,IND
      DIF=XZ-ZX(I)
      IF(DIF-.000001)406,406,491
  491 Y=Y+C(I+4)*(DIF)**3
      TDERI=TDERI+3.*C(I+4)*(DIF)**2
      SDERI=SDERI+6.*C(I+4)*DIF
  409 CONTINUE
  406 XZ=XZ*FINT+RORIG
      RDERI=TDERI/FINT
      SDERI=SDERI/(FINT*FINT)
      IF(K2)438,439,438
  439 IF(SENSE SWITCH 4)410,411
  410 IF(IDNT-2)437,436,436
  437 PUNCH 107,ZT,XZ,Y,RDERI
      GO TO 412
  436 PUNCH 109,ZT,XZ,Y,RDERI
      GO TO 412
  411 IF(IDNT-2)441,440,440
  441 PUNCH 107,ZT,XZ,Y,RDERI,SDERI
      GO TO 412
  440 PUNCH 109,ZT,XZ,Y,RDERI,SDERI
      GO TO 412
  438 PUNCH 111,ISP(IK),XZ,Y
  412 IF(XZ-TOT)497,51,51
  51  PUNCH 110,SIX
      PUNCH 103,RORIG,Y
```

```
      GO TO 205
497   IF(K3)52,415,52
52    PUNCH 108,FIVE
      K3=0
415   IF(KSR-1)174,175,176
175   IF(XSEG(1)-XZ)174,178,174
178   SEG=SEGXS(1)/FINTX
      KSR=0
      GO TO 174
176   DO 177 I=1,KSR
      IF(XSEG(I)-XZ)177,179,177
179   SEG=SEGXS(I)/FINTX
      IF(KSR-I)177,180,177
180   KSR=0
177   CONTINUE
174   IF(IDNT-3)186,185,185
186   IF(OLD+SEG-ZX(IND+1))416,417,418
418   IF(K)419,419,420
420   IF(K-KID)419,421,421
421   IF(ZX(IND+1)-XE(KID))419,422,423
423   XZ=XE(KID)
      K2=1
      IF(K-KID)405,424,424
424   KID=KID+1
      IK=IK+1
      GO TO 405
422   IND=IND+1
      GO TO 423
419   IND=IND+1
      K2=0
      XZ=ZX(IND)
      GO TO 709
417   IF(K)430,430,428
428   IF(K-KID)430,429,429
429   IF(ZX(IND+1)-XE(KID))430,431,423
431   OLD=OLD+SEG
      GO TO 422
430   OLD=OLD+SEG
      GO TO 419
416   IF(K)432,432,433
433   IF(K-KID)432,434,434
434   IF(OLD+SEG-XE(KID))432,435,423
435   OLD=OLD+SEG
      GO TO 423
432   XZ=OLD+SEG
      OLD=OLD+SEG
      K2=0
709   IF(IDNT-9)405,710,405
710   XX=XZ
```

```
      GO TO 360
C     * * E) STANDARD CUBIC COEFFICIENTS FOR A WATER LINE * *
  801 READ 102,ZT
      PUNCH 107,ZT
      PUNCH 120
      NA=N
      RORIG=XORIG
      FINT=FINTX
      GO TO 804
  503 IF(IDNT-7)811,810,810
  810 DO 805 I=1,NA
      INX=I-1
      IF(S-ZX(I))506,805,805
  805 CONTINUE
      GO TO 506
  811 INX=0
  506 XE(1)=C(1)
      XE(2)=C(2)
      XE(3)=C(3)
      XE(4)=C(4)
      IF(INX-1)508,507,507
  507 DO 504 I=1,INX
      XE(1)=XE(1)-C(I+4)*ZX(I)**3
      XE(2)=XE(2)+3.*C(I+4)*ZX(I)*ZX(I)
      XE(3)=XE(3)-3.*C(I+4)*ZX(I)
      XE(4)=XE(4)+C(I+4)
      IF(I-INX)504,508,508
  504 CONTINUE
  508 IF(IDNT-7)807,806,806
  806 XS=S
      IF(XS-F)23,22,22
   22 XS=F
   23 Y=XE(1)+XE(2)*XS+XE(3)*XS*XS+XE(4)*XS*XS*XS
      IF(IDNT-8)840,841,841
  840 XT=XS*FINTX+XORIG
      PUNCH 107,ZT,XT,Y,TOL
      GO TO 842
  841 XT=XS*FINTZ+ZORIG
      PUNCH 109,ZT,XT,Y,TOL
  842 IF(XS-F)34,205,205
   34 AA=3.*XE(4)*S-XE(3)
      AC=XE(3)*S*S+XE(4)*S*S*S
      AAA=2.*XE(4)*XS*XS*XS-AA*XS*XS-2.*XE(3)*S*XS+AC
      DER=(XE(2)+2.*XE(3)*XS+3.*XE(4)*XS*XS)/FINTX
      Y=AAA*AAA-TOL*TOL*(1.+DER*DER)
      IF(Y)4,12,4
    4 H=2.*TOL
    5 CA=Y
      XS=XS+H
```

```
      IF(XS-ZX(INX+1))7,7,44
 44   S=ZX(INX+1)
      GO TO 810
 7    AAA=2.*XE(4)*XS*XS*XS-AA*XS*XS-2.*XE(3)*S*XS+AC
      DER=(XE(2)+2.*XE(3)*XS+3.*XE(4)*XS*XS)/FINTX
      Y=AAA*AAA-TOL*TOL*(1.+DER*DER)
      IF(CA*Y)9,12,5
 9    IF(ABS(H)-.0001)10,11,11
 11   H=-H/2.
      GO TO 5
 10   XS=XS-H/2.
 12   RAD=8.*XE(3)*XE(4)*XS+12.*XE(4)**2*XS**2-2.*XE(3)*XE(4)*S
      RAD=SQRT(RAD-3.*XE(4)*XE(4)*S*S+XE(3)*XE(3))
 13   XX=-.5*(S+(XE(3)+RAD)/XE(4))
      IF(XX-S)14,15,15
 14   RAD=-RAD
      GO TO 13
 15   IF(XX-ZX(INX+1))19,44,44
 19   IF(XX-F)16,17,17
 16   S=XX
      GO TO 806
 17   S=F
      GO TO 806
 807  IF(INX)280,280,281
 280  S=RORIG
      F=ZX(1)*FINT+RORIG
      GO TO 282
 281  S=ZX(I)*FINT+RORIG
      F=ZX(I+1)*FINT+RORIG
 282  DO 283 I=2,4
 283  XE(I)=XE(I)/FINT**(I-1)
      PUNCH 122,XE(1),XE(2),XE(3),XE(4),S,F
      IF(INX-NA+2)509,509,205
 509  INX=INX+1
      GO TO 506
C     * * H) SEGMENTATION OF A FRAME* *
 820  READ 102,ZT,S,F,TOL
      S=(S-ZORIG)/FINTZ
      F=(F-ZORIG)/FINTZ
      NA=M
      PUNCH 112
      GO TO 903
C     * * F) STANDARD CUBIC COEFFICIENTS FOR A FRAME  **
 831  READ 102,ZT
      NA=M
      PUNCH 109,ZT
      PUNCH 120
      RORIG=ZORIG
```

```
      FINT=FINTZ
  402 INZ=MP
      GO TO 903
C     * * G) SEGMENTATION OF A WATER LINE * *
  800 READ 102,ZT,S,F,TOL
      S=(S-XORIG)/FINTX
      F= (F-XORIG)/FINTX
      NA=N
      PUNCH 113
      GO TO 804
C     * * D) OFFSETS OF A BUTTOCK * *
  234 READ 102,BUTTK
      PUNCH 121
      GO TO 1360
C     * * C) OFFSETS OF A DIAGONAL PLANE * *
  231 READ 102, ANGLE
      TAN=ANGLE*3.14159/180.
      SI=SIN(TAN)
      CO=COS(TAN)
      TAN=-SI/CO
      PUNCH 117
 1360 SEG=SEGX/FINTX
      SEGTZ=SEGZ/FINTZ
      XX=0.
      INZ=MP
      GO TO 360
  321 K=1
      KID=1
  452 ZXZ=XZ*FINTZ+ZORIG
      Y=C(1)+C(2)*XZ+C(3)*XZ*XZ+C(4)*XZ**3
      IF(IND-1)465,454,455
  454 Y=Y+C(5)*(XZ-Z(1))**3
      GO TO 465
  455 DO 456 I=1,IND
  456 Y=Y+C(I+4)*(XZ-Z(I))**3
  465 IF(IDNT-4)478,477,477
  477 IF(BUTTK)480,485,480
  485 ZXZ=ZORIG
      GO TO 457
  480 Y=Y-BUTTK
      GO TO 453
  478 Y=TAN*(TOTZ-ZXZ)+Y
  453 IF(ABS(Y)-.005)457,457,479
  479 GO TO (481,482),KID
  481 KID=2
      IF(Y)473,457,457
  482 GO TO (471,472),K
  471 IF(Y)473,457,474
```

```
 473 IF(ZXZ+SEGZ-TOTZ)483,483,484
 484 ZXZ=TOTZ
     GO TO 457
 483 OLD=XZ
     XZ=XZ+SEGTZ
     GO TO 458
 474 K=2
     GO TO 475
 472 IF(Y)476,457,475
 475 XT=XZ
     XZ=XZ-(ABS(XZ-OLD))/2.
     OLD=XT
     GO TO 458
 476 XT=XZ
     XZ=XZ+(ABS(XZ-OLD))/2.
     OLD=XT
 458 DO 459 I=1,M
     IF(XZ-Z(I))452,452,459
 459 IND=I
     GO TO 452
 457 XZ=XX*FINTX+XORIG
     IF(IDNT-4)467,468,468
 467 Y=(TOTZ-ZXZ)/CO
     PUNCH 114,ANGLE,XZ,Y,ZXZ
     GO TO 466
 468 PUNCH 119,BUTTK,XZ,ZXZ
 466 IF(XZ-TOTX)497,64,64
 64  PUNCH 110,SIX
 66  PUNCH 103,XORIG,ZXZ
     GO TO 205
 185 IF(XX+SEG-X(K2+1))463,462,461
 461 K2=K2+1
     XX=X(K2)
 324 XZ=0.
     IND=0
     GO TO 360
 462 K2=K2+1
 463 XX=XX+SEG
     GO TO 324
C    * * I) OFFSETS OF LONGITUDINAL ELEMENTS  * *
 700 READ 124
     PUNCH 124
     PUNCH 125
     DO 701 I=1,NP
     READ 102,CZ(I)
 701 CONTINUE
     DO 707 I=1,N
 707 ZX(I)=X(I)
```

```
      K=0
      TOT=TOTX
      SEG=SEGX/FINTX
      XX=0.
      GO TO 360
  702 ZPCH=CZ(1)+CZ(2)*XX+CZ(3)*XX*XX+CZ(4)*XX**3
      IF(MAX-1)1000,704,704
  704 DO 705 I=1,MAX
      ZPCH=ZPCH+CZ(I+4)*(XX-X(I))**3
      IF(MAX-I)1000,1000,705
  705 CONTINUE
 1000 ZZ=(ZPCH-ZORIG)/FINTZ
      GO TO 740
  722 Y=C(1)+C(2)*ZZ+C(3)*ZZ*ZZ+C(4)*ZZ**3
      IF(MAZ-1)703,724,724
  724 DO 725 I=1,MAZ
      Y=Y+C(I+4)*(ZZ-Z(I))**3
      IF(MAZ-I)703,703,725
  725 CONTINUE
  703 XPCH=(XX*FINTX)+XORIG
      PUNCH 101,XPCH,ZPCH,Y
      XZ=XX
      IF(XPCH-TOT)186,205,205
      END
```

Section VI

GOBACK 2
3-D PROFILE

A. OPERATING INSTRUCTIONS

This version of GOBACK will accept coefficients of a surface equation such as given in Fig. D-2, modified as shown in Section IV, for end profile requirements. The equation must be single splined in the x direction and may be single or double splined in the z direction.

The following data can be calculated with this program:

- Offsets, first and second derivatives along a waterline at a given interval
- Offsets, first and second derivatives along a station at a given interval
- Offsets at a given interval along buttocks as given in Section IV-B of this appendix.

Fortran Input Symbols

Symbol		Definition
XO	-	The actual full scale coordinate of the first station of the surface
ZO	-	The actual full scale z coordinate of the first waterline
FINTX	-	This value is used as a scale factor in the x direction. If the surface equation is scaled so the stations are one unit apart, FINTX equals the actual full scale station interval (x_1-x_o). If the stations of the surface equation are less than one unit apart FINTX becomes some multiple of the station spacing. For example, if the stations in the equation are 1/4 unit apart FINTX becomes 4 times the actual full scale station spacing $[4(x_1-x_o)]$

FINTZ - Same definition as FINTX, except in the z direction $(z_1 - z_0)$.

M - The total number of points of discontinuity along a station (points where z coefficients are added) including the points at the first and last waterlines. For example, if a surface containing seven waterlines were single splined, M would equal seven since there are third derivative discontinuities at each waterline. If the seven-waterline surface were double splined, M would equal four, since there are discontinuities only at waterlines 0,2,4, and 6 .

N - The total number of points of discontinuity along a waterline (points where x coefficients are added). The example used for M is valid except using stations instead of waterlines.

K - The number of coefficients in the profile equation

NAB - This value tells the program whether the surface has been single splined in the z direction (NAB = +1) or or double splined in the z direction (NAB = -1)

SEGX - Desired interval between consecutive calculated offsets along waterlines, buttocks, and diagonal planes.

SEGZ - Desired interval between consecutive calculated offsets along stations.

POINT - The actual full scale interval over which the end condition is to be effective. Usually less than or equal to the first station interval (D in Section IV)

PWR1 - In the end condition function of Section IV

$$\left(T(x,z) = \left[1 - \left(\frac{D+G(z)-x}{D} \right)^{r}_{\#} \right]^{p}_{\#} \right)$$

PWR1 is the value of r . It is nearly always equal to 3 .

PWR2 - Equals the power (P) to which the function $T(x,z)$ is to be raised.

CZ - The coefficients of the profile equations. These coefficients must be scaled the same and have the same origin as the surface equation.

A - The coefficients of the surface equation produced by the linear program. There are (M+2) (N+2) coefficients.

Z	-	z coordinates of waterlines where coefficients are added, plus that of the last waterline. There are (M-1) since the value for the first waterline isn't included.
X	-	Same as Z except for stations (N-1)
ZP	-	If the surface equation has been double splined in the z direction (NAB = -1), the z coordinates of the waterlines where new coefficients are added must be read in. These are ZP and there are (K-3). If the equation is single splined in the z direction (NAB = +1) and these are not necessary.
IDENT	-	Code which tells the program what data is required from the surface
ZT	-	z coordinate of a waterline along which data is to be calculated
NBOW	-	An indicator for telling the program if the buttocks will be single valued or multi-valued. If NBOW = 1 the case must be that shown in Fig. D-5a, Section IV-B. If NBOW = 2 the program will expect to find the more complicated cases.
BUTTK	-	The y distance from the centerplane of the ship to a buttock along which heights are to be calculated

Input Data Cards

There are two distinct kinds of sets of data used for input to GOBACK 2. The first set consists entirely of data describing the surface equation to the program. No output is produced from this set. The second set of data consists of packets of data cards. Each packet describes some information required from the surface and gives the geometric data necessary to obtain the information from the surface equation. Only one of the first sets of data are entered per problem. There may be many small packets, each of which calls for offsets along a waterline or station or perhaps standard cubic coefficients, etc.

There are limitations on some of the input parameters of the

program. These limitations follow:

Variable	Minimum	Maximum
M (no. of waterlines)	3	11
N (no. of stations)	3	15
K (no. of coefficients in profile equation)	1	16

In describing the various data cards, the actual FORTRAN format field description is used in most cases. These fields come consecutively across the card with no gaps or blank columns between, except where indicated. The field descriptions are the FORTRAN F field, which uses the FORTRAN fixed point decimal number, and the I field that used the FORTRAN integer number, which is always right justified. The card numbers are not punched on the data cards.

First Data Set

This data set is the one that describes the surface equation

Contents of Card									Card No.
The first card is a header card and may contain any alphanumeric description of the problem in columns 1-50 .									1
Format	F15.8	F15.8	F15.8	F15.8	I5	I5	I5	I5	2
Variable	XO	ZO	FINTX	FINTZ	M	N	K	NAB	
Format	F15.8	F15.8	F15.8	F15.8	F15.8	I5			3
Variable	SEGX	SEGZ	POINT	PWR1	PWR2	NBOW			
Format	F15.8								next K cards
Variable	CZ								
Format	F15.8								next (M+2)(N+2) cards
Variable	A								
Format	F15.8								next (M-1) cards
Variable	Z								
Format	F15.8								next (N-1) cards
Variable	X								

Format F15.8 next
Variable ZP (K-3)

(This set of K-3 cards need be entered only if NAB = -1 , see Input Symbol Definition)

This completes the first data set.

The coefficients of the surface equation (A) are presented in the following order (See Fig. D-2):

$$A_{00}, A_{01}, A_{02}, A_{03}, A_{04}, \cdots, A_{10}, A_{11}, A_{12}, A_{13},$$

$$A_{14}, \cdots, A_{20}, A_{21} - A_{22}, A_{23}, A_{24}, \cdots, A_{31}, A_{32},$$

$$A_{33}, A_{34}, \cdots, A_{40}, \cdots, \ldots\ldots\ldots .$$

This is generally the order in which they will be received from the L.P. Any coefficients that weren't in the final solution must have a zero value included in the data deck.

Second Data Set

This data set contains the packets of cards, each of which describes some information to be extracted from the surface. Any number of these packets may be used in a problem. They may be entered in any desired order by simply stacking them behind the first data set in the card reader. A description of each data packet follows. The first card for each of these packets is an identification card and contains a specific value of IDENT in Column 4.

Packet for Offsets on a Waterline

Contents of Card	Card No.
The first card is the identification card and contains a 1 in Column 4	1
Format F15.8 Variable ZT	2

Packet for Offsets of a Station

Contents of Card			Card No.
This card has a 2 in Column 4			1
Format	I4	F15.8	2
Variable	K	XT	

Packet for Offsets of a Buttock

Contents of Card		Card No.
This card contains a 4 in Column 4		1
Format	F15.8	2
Variable	BUTTK	

Output Data

The output data for the different types of information requested is given below. Since the output data consists of offsets of curves which may need to be plotted, GOBACK 2 includes cards which place the plotter pen up or down at the proper times. The data deck is arranged in order and punched in such a format that the deck can be directly plotted using the plotting program of Appendix F.

Offsets of a Waterline

The first N+2 cards punched when the offsets of a waterline are called for contain the coefficients for the two-dimensional Thielheimer equation of the waterline. Following this is a header card and finally cards each containing:

(1) A waterline identification (WL)
(2) The x coordinate of the offset
(3) The offset on the waterline
(4) The first derivative of the waterline
(5) The second derivative of the waterline

Offsets of a Station or Frame

Information corresponding to that of a waterline is punched. The frame identification (FR) and the z coordinate of the offset are given.

Offsets of a Buttock

First, a header card is punched and then cards each containing the following:

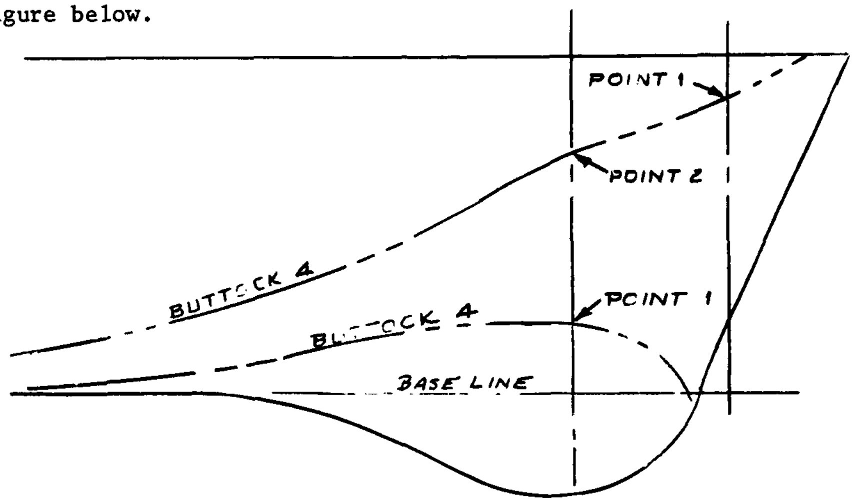
(1) An identification of the buttock

(2) The x coordinate of the offset

(3) The z height of the offset

(4) The point number on the frame

If the buttock is multi-valued on a frame, the points are numbered in Columns 48 and 49 of the card. The points are numbered consecutively beginning with the lowest (least z) value on each frame. If a buttock is multivalued during only part of its length, the series of numbers describing it may change as shown in the figure below.



Sense Switches

All sense switches are ignored.

B. SAMPLE PROBLEM

The sample problem was taken from a surface describing the bow of the DLG-26 class frigate. The surface has eleven waterlines and five stations. It has been double splined in both the x and z directions. The offsets of one waterline, one station, and one buttock have been solved for.

In this case the buttock is double valued overpart of its length. The offsets for the two lines must be separated before plotting. This can be done by examining their z coordinates.

* * SAMPLE INPUT * *

```
*        COMPLETE BOW DLG
   0.0            0.0            5.10           8.             6    3
  13   -1
   1.0            2.            1.275           3.             .3333333
        2
   .8562
  -.272763473
 0.0
  -.6288
   .1531
  -.0704
  -.0041
 0.0
 0.0
 0.0
0.0
 0.0
 0.0
-      7.16765334
     15.10834002
-      3.90044334
 0.0
       1.37436000
       5.17799440
-     21.63735908
       6.09769242
 0.0
-      1.46282033
       2.89710319
      10.92294755
-      3.04203734
 0.0
        .01033209
-      2.33844915
-      1.72304778
        .46882580
 0.0
        .26489650
       3.81770188
```

Coefficients of the profile equation (lines .8562 through the last 0.0)

Coefficients of the surface equation (lines -7.16765334 through 3.81770188)

-.35464391	
.12961316	
0.0	
-.57317627	
-1.54632108	
2.35139965	
-.65726751	
0.0	
.35806726	
.34638152	
-.16817131	
.00715955	
-.00013420	
-.04213764	
-.44640127	
-.59797708	
.23047406	
0.0	
-.13067829	
8.	Waterlines where new z coefficients are to be added (z)
16.	
24.	
32.	
40.	
10.2	Stations where new x coefficients are to be added
20.4	
4.	Waterlines where new coefficients of the profile are to be added (zP) (Included because NAB = -1
8.	
12.	
16.	
20.	
24.	
28.	
32.	
36.	
40.	First Data Set
1	Data Packet for Waterline — Second Data Set
28.0	
2	Data Packet for Station
7.5	
4	Data Packet for Buttock
4.	

** SAMPLE OUTPUT **

```
*       COMPLETE BOW DLG
      .65988975
     1.68165847
      .08525161
     -.00001677
     -.01417503
 IDENT.          X                     Y              FIRST DER.     SECOND DER.
WL   28.00-    2.29857000          0.00000000        0.00000000      0.00000000
PEN DOWN  5000.00000000
WL   28.00-    1.29857000           .23643444         .32099980       .00823214
WL   28.00-     .29857000           .56173237         .32777970       .00655552
WL   28.00      .70142999           .89278971         .33433484       .00655476
WL   28.00     1.70142999          1.23040181         .34088923       .00655400
WL   28.00     2.70142999          1.57456792         .34744285       .00655324
WL   28.00     3.70142999          1.92528728         .35399572       .00655248
WL   28.00     4.70142999          2.28255912         .36054783       .00655172
WL   28.00     5.70142999          2.64638268         .36709917       .00655096
WL   28.00     6.70142999          3.01675722         .37364976       .00655021
WL   28.00     7.70142999          3.39368197         .38019959       .00654945
WL   28.00     8.70142999          3.77715617         .38674867       .00654869
WL   28.00     9.70142999          4.16717906         .39329698       .00654793
WL   28.00    10.20000000          4.36407894         .39656149       .00654755
WL   28.00    11.19999999          4.76380722         .40278809       .00590563
WL   28.00    12.19999999          5.16944115         .40837277       .00526372
WL   28.00    13.19999999          5.58033880         .41331553       .00462180
WL   28.00    14.19999999          5.99585825         .41761638       .00397988
WL   28.00    15.19999999          6.41535759         .42127531       .00333797
WL   28.00    16.19999999          6.83819491         .42429233       .00269605
WL   28.00    17.19999999          7.26372829         .42666742       .00205414
WL   28.00    18.19999999          7.69131580         .42840061       .00141222
WL   28.00    19.19999999          8.12031554         .42949187       .00077030
WL   28.00    20.19999999          8.55008558         .42994122       .00012839
WL   28.00    20.40000000          8.63607554         .42995406      0.00000000
PEN UP    6000.00000000
GO TO     -    2.29857000          8.63607554
     6.61527891
   -13.45460022
    12.38146087
    -3.85844631
     3.57647199
```

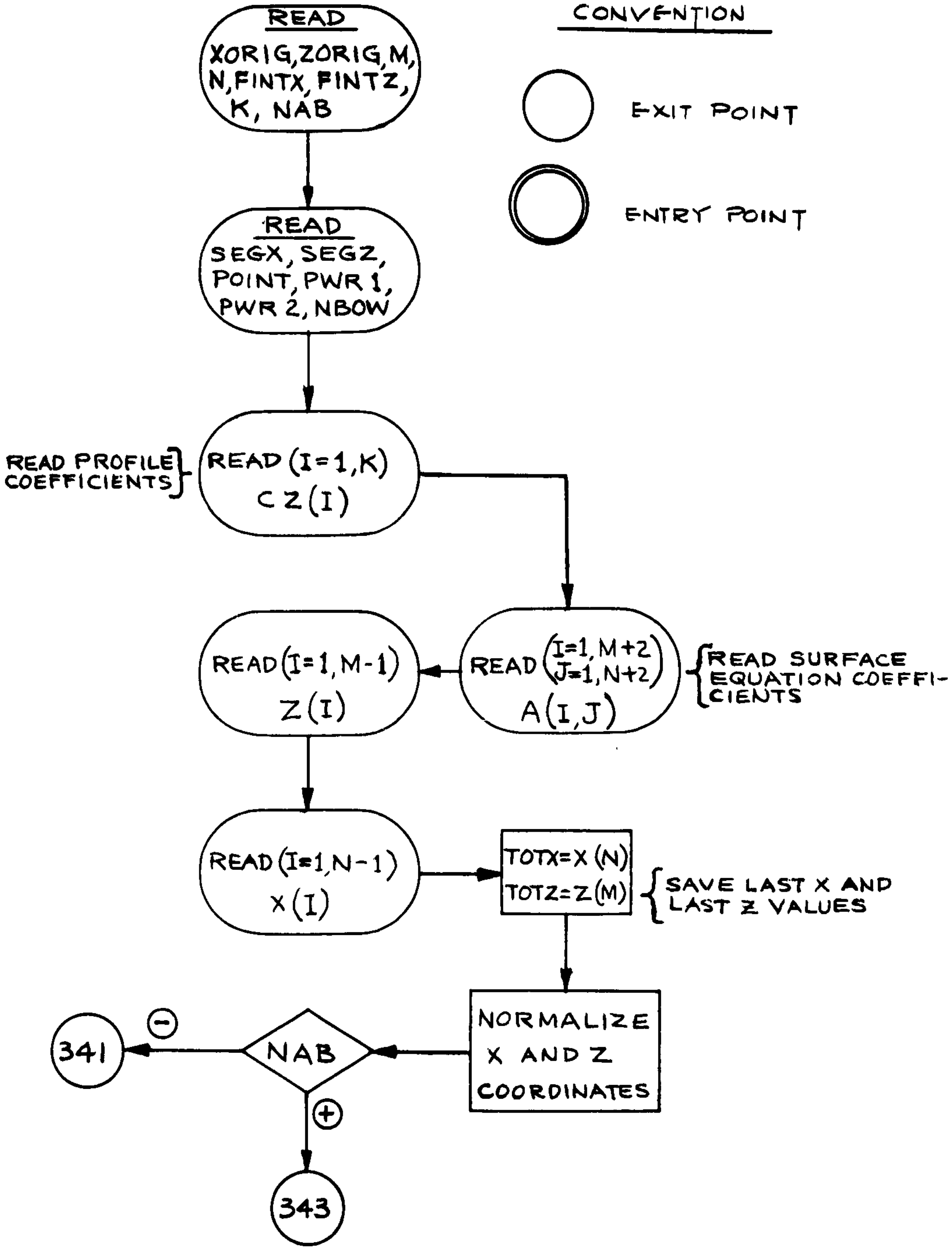
.49019330
.11412742
-.82734926

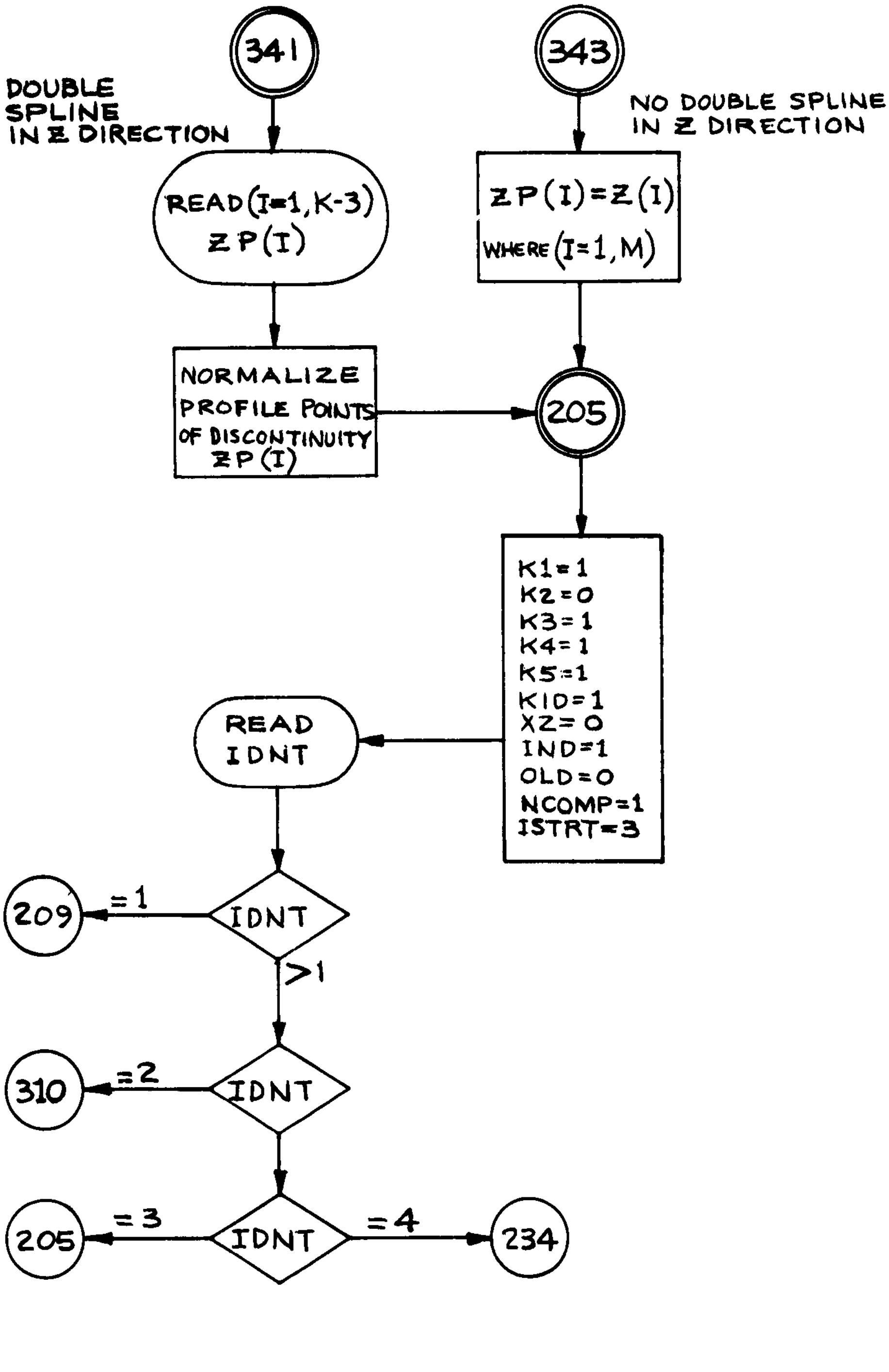
IDENT.	Z	Y	FIRST DER.	SECOND DER.
FR 7.50	0.00000000	6.61527891	-1.68182502	.38692065
PEN DOWN	5000.00000000			
FR 7.50	2.00000000	3.96518193	-.99841605	.29648831
FR 7.50	4.00000000	2.50103822	-.49587176	.20605598
FR 7.50	6.00000000	1.86111844	-.17419213	.11562364
FR 7.50	8.00000000	1.68369324	-.03337717	.02519131
FR 7.50	10.00000000	1.66291566	.01039666	.01858253
FR 7.50	12.00000000	1.71646822	.04095296	.01197376
FR 7.50	14.00000000	1.81791584	.05829172	.00536499
FR 7.50	16.00000000	1.94082342	.06241293	.00124378
FR 7.50	18.00000000	2.06641513	.06480549	.00363634
FR 7.50	20.00000000	2.20655225	.07695833	.00851648
FR 7.50	22.00000000	2.38075530	.09887142	.01339661
FR 7.50	24.00000000	2.60854480	.13054478	.01827674
FR 7.50	26.00000000	2.91122454	.17465327	.02583174
FR 7.50	28.00000000	3.31723123	.23387175	.03338673
FR 7.50	30.00000000	3.85678487	.30820021	.04094172
FR 7.50	32.00000000	4.56010542	.39763866	.04849672
FR 7.50	34.00000000	5.44448553	.48279610	.03666071
FR 7.50	36.00000000	6.47550851	.54428153	.02482471
FR 7.50	38.00000000	7.60583035	.58209496	.01298870
FR 7.50	40.00000000	8.78810703	.59623637	.00115270
PEN UP	6000.00000000			
GO TO	0.00000000	8.78810703		

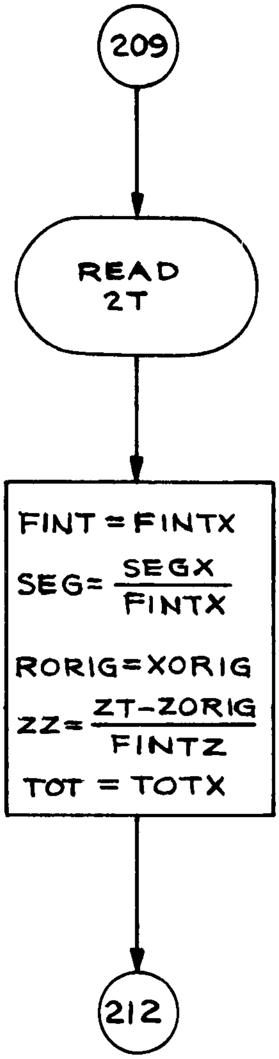
IDENT.	X	Z	
BK 4.00	.36766906	40.00000000	1
PEN DOWN	5000.00000000		
BK 4.00	1.36766906	38.35546875	1
BK 4.00	2.36766906	36.87158203	1
BK 4.00	3.36766906	35.52490234	1
BK 4.00	4.36766906	34.27441406	1
BK 4.00	5.36766906	.31738281	1
BK 4.00	5.36766906	33.07373046	2
BK 4.00	6.36766906	1.21630859	1
BK 4.00	6.36766906	31.87304687	2
BK 4.00	7.36766906	1.89062500	1
BK 4.00	7.36766906	30.62207031	2
BK 4.00	8.36766906	2.37829589	1
BK 4.00	8.36766906	29.29235839	2
BK 4.00	9.36766906	2.69628906	1
BK 4.00	9.36766906	27.86230468	2
BK 4.00	10.20000000	2.82910156	1
BK 4.00	10.20000000	26.57812499	2
BK 4.00	11.19999999	2.81616210	1
BK 4.00	11.19999999	24.89819335	2

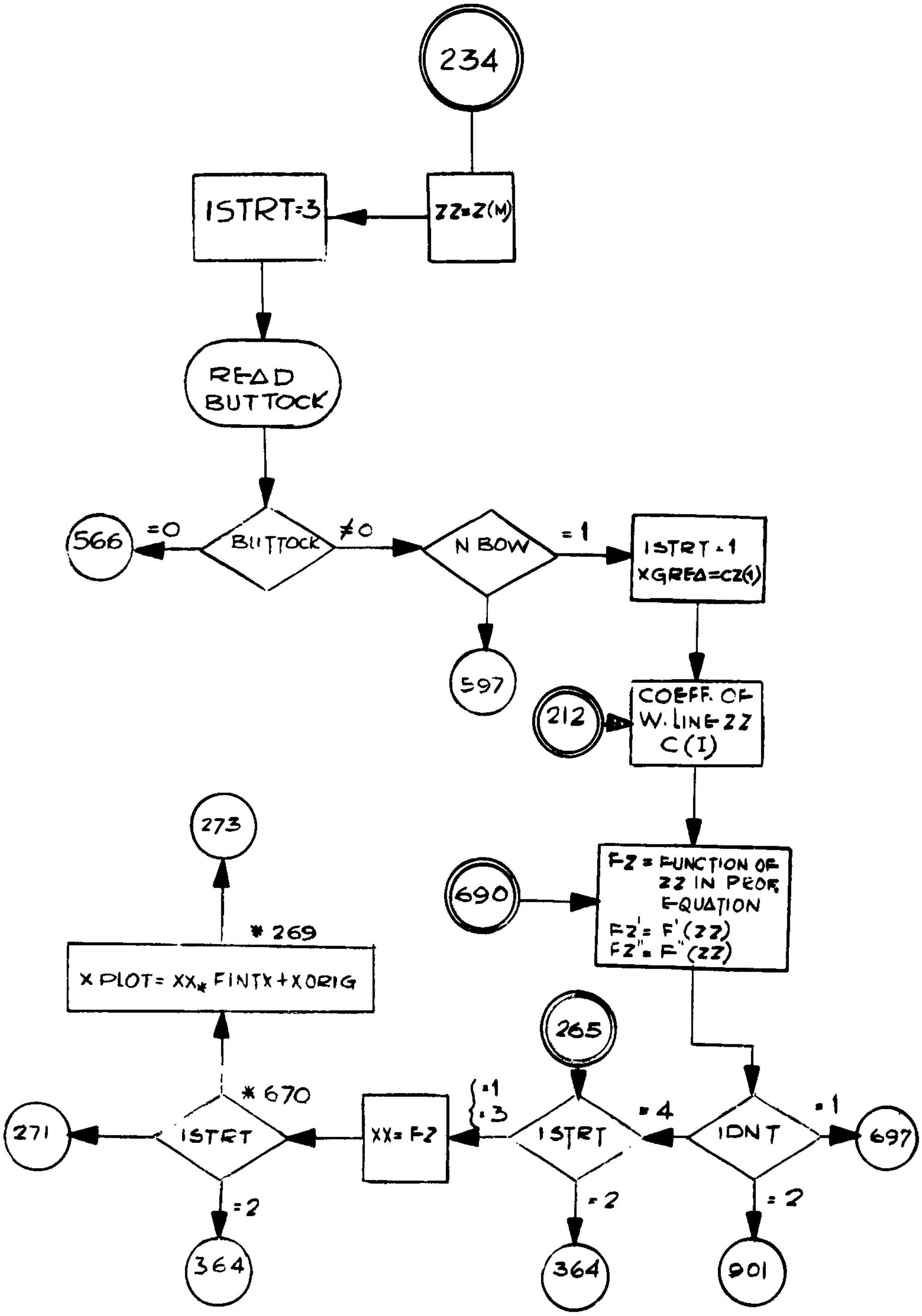
BK	4.00	12.19999999	2.61108398	1
BK	4.00	12.19999999	23.02709960	2
BK	4.00	13.19999999	2.20458984	1
BK	4.00	13.19999999	20.85302734	2
BK	4.00	14.19999999	1.57788085	1
BK	4.00	14.19999999	18.12866210	2
BK	4.00	15.19999999	.70214843	1
BK	4.00	15.19999999	14.48730468	2
BK	4.00	16.19999999	11.06445312	1
BK	4.00	17.19999999	9.12500000	1
BK	4.00	18.19999999	7.85693359	1
BK	4.00	19.19999999	6.72802734	1
BK	4.00	20.19999999	5.40087890	1
BK	4.00	20.40000000	5.08984375	1
PEN UP		6000.00000000		
GO TO		.36766906	5.08984375	

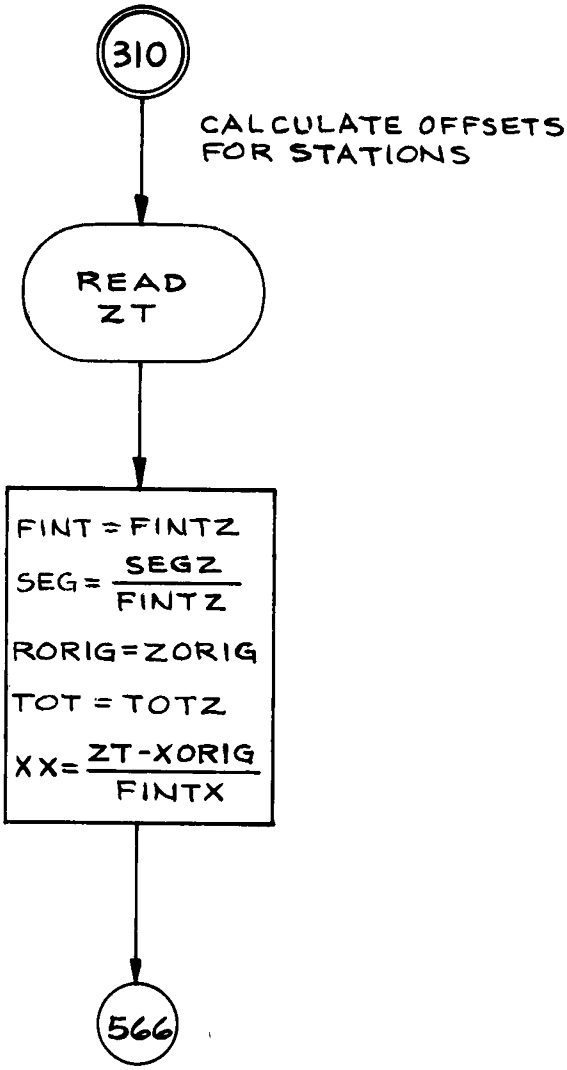
C. **FLOW DIAGRAM**

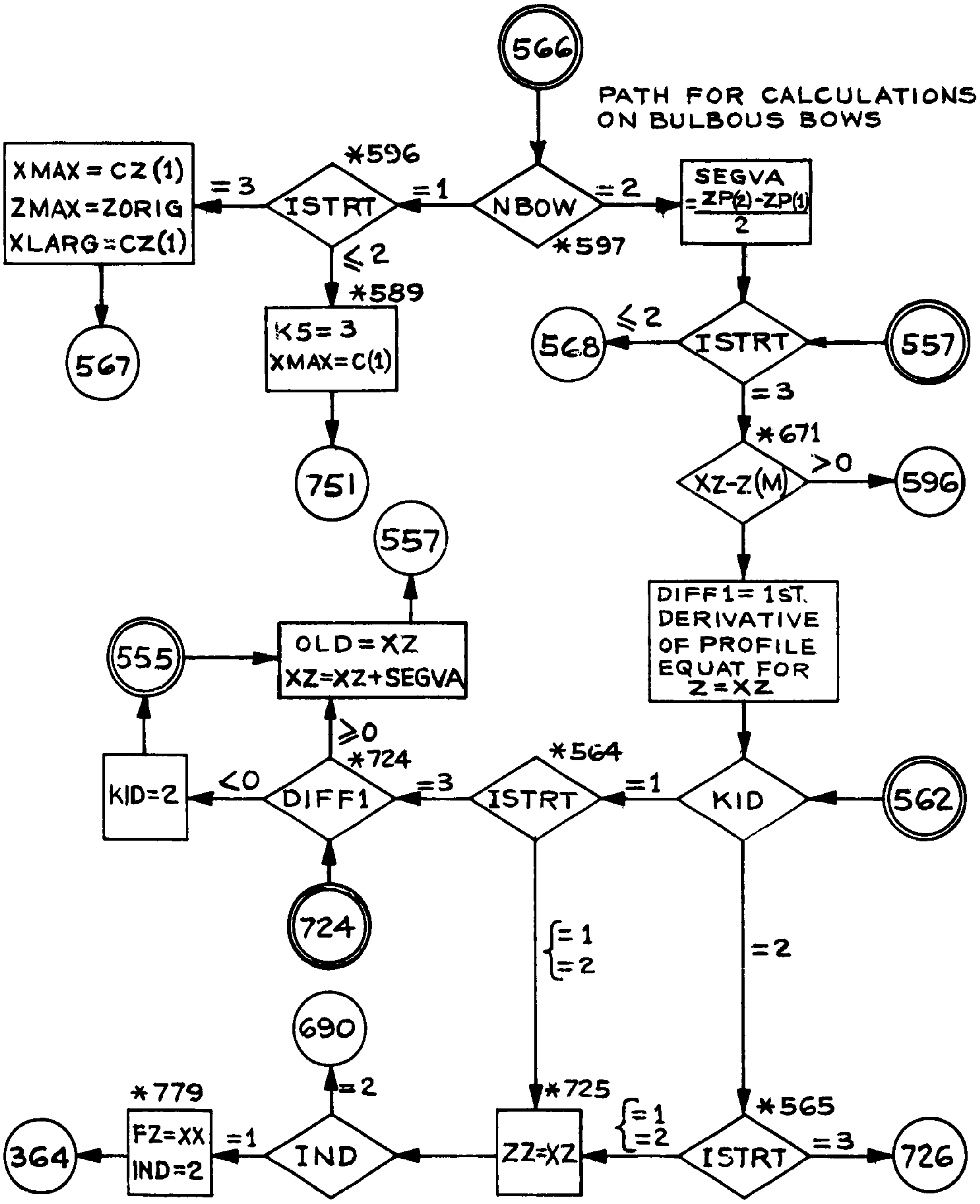


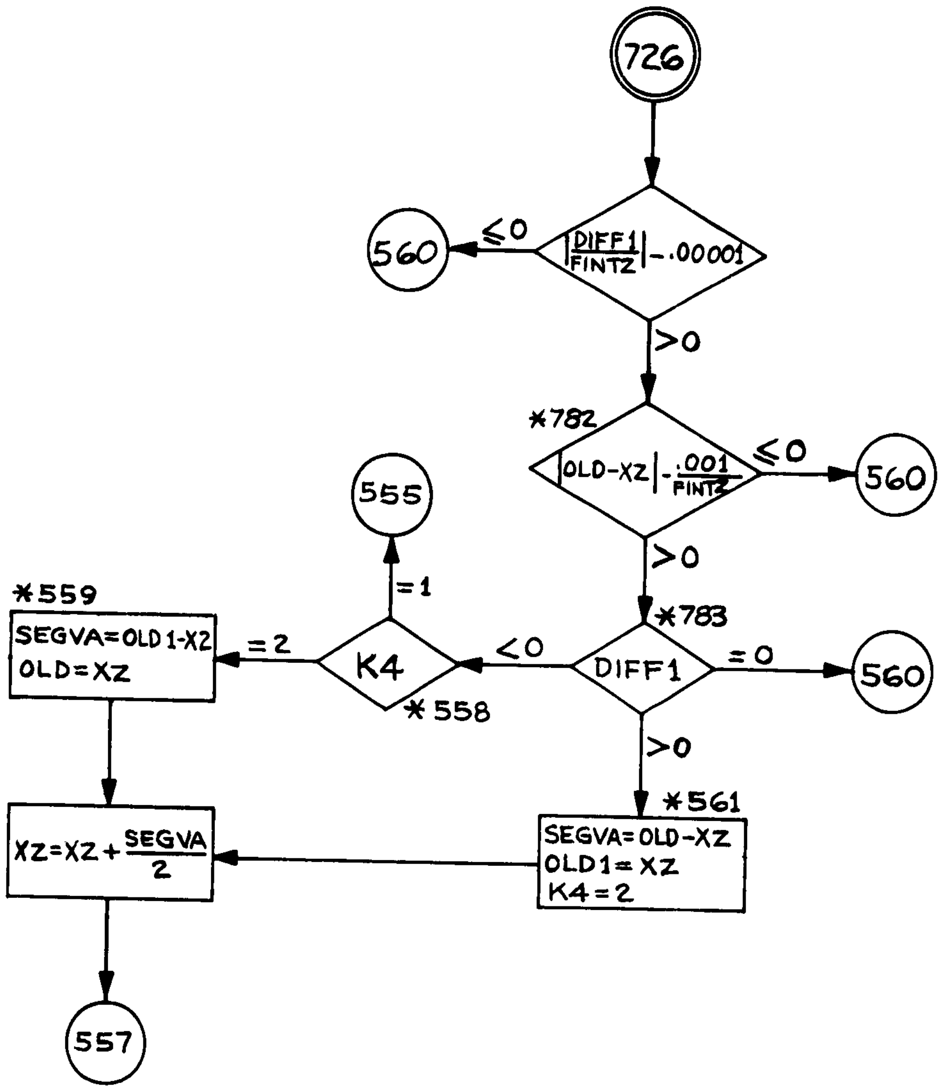

341
DOUBLE SPLINE IN Z DIRECTION
READ (I=1, K-3) ZP(I)
NORMALIZE PROFILE POINTS OF DISCONTINUITY ZP(I)
343
NO DOUBLE SPLINE IN Z DIRECTION
ZP(I)=Z(I) WHERE (I=1,M)
205
K1=1
K2=0
K3=1
K4=1
K5=1
K10=1
XZ=0
IND=1
OLD=0
NCOMP=1
ISTRT=3
READ IDNT
IDNT
=1
209
>1
IDNT
=2
310
IDNT
=3
205
=4
234

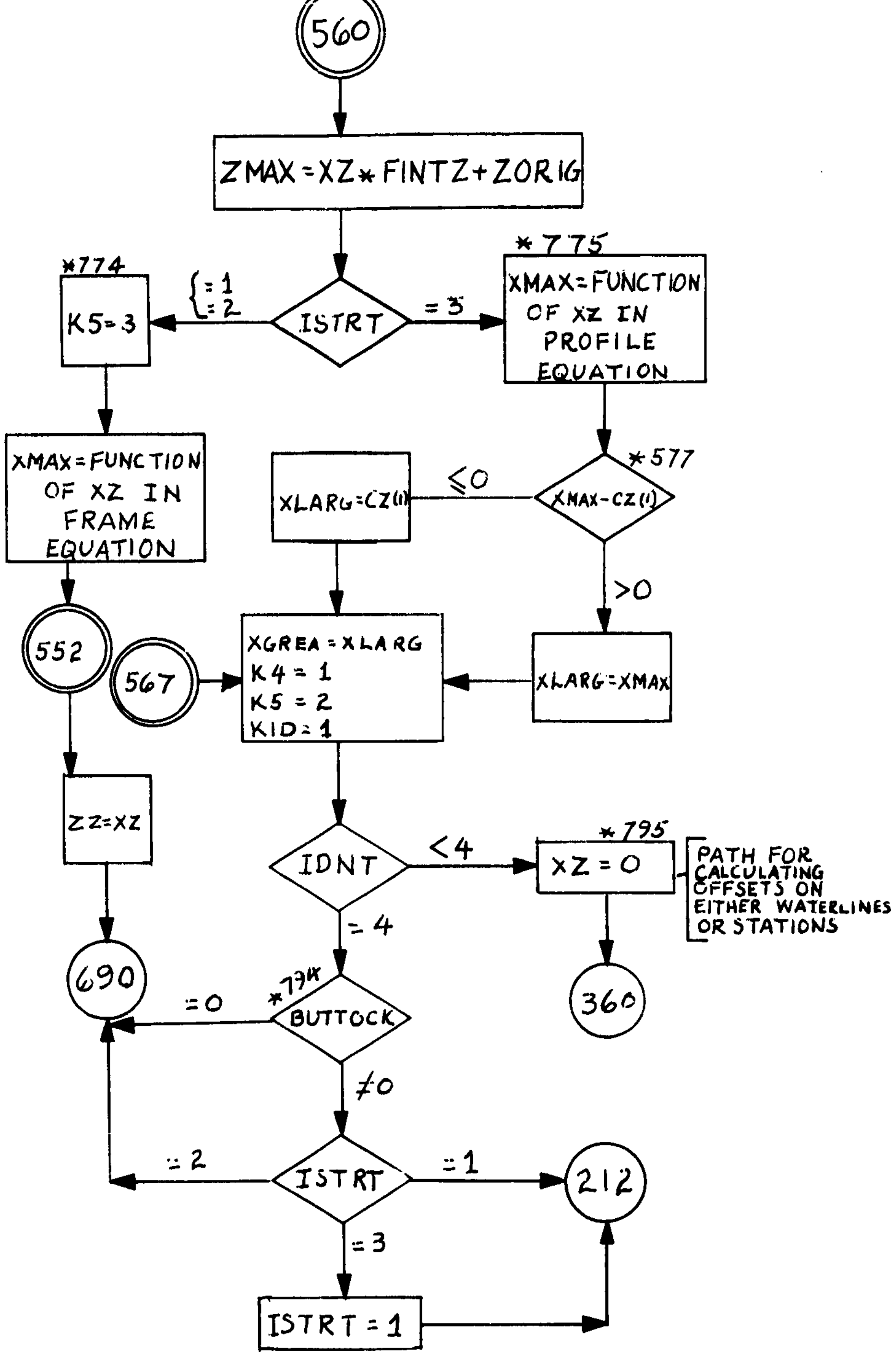

209
READ
ZT
FINT = FINTX
SEG = SEGX / FINTX
RORIG = XORIG
ZZ = ZT-ZORIG / FINTZ
TOT = TOTX
212

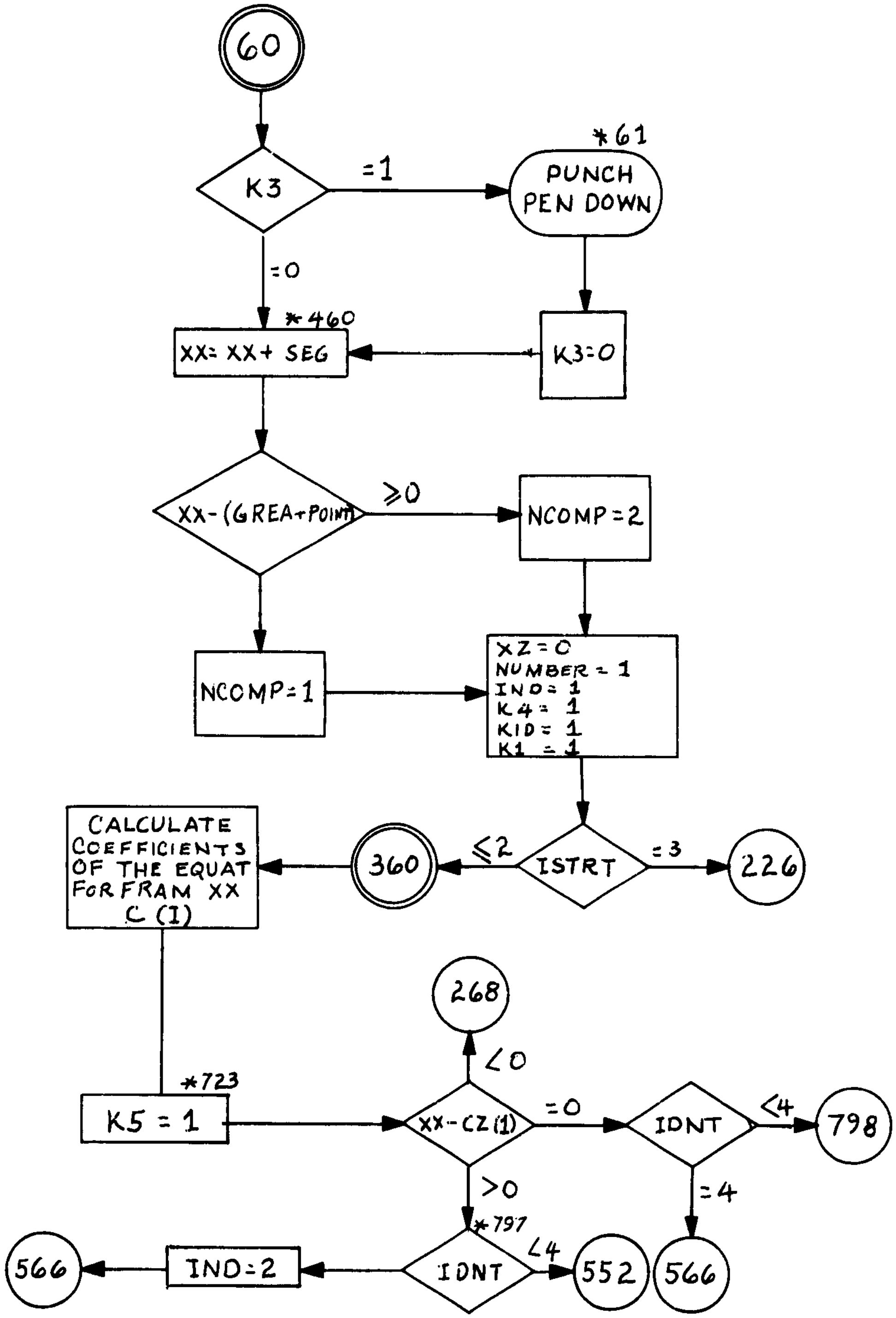

234
ZZ=Z(M)
ISTRT=3
READ BUTTOCK
BUTTOCK
=0
≠0
566
N BOW
=1
597
ISTRT=1 XGREA=CZ(1)
212
COEFF. OF W. LINE ZZ C(I)
690
FZ = FUNCTION OF ZZ IN PEOR EQUATION
FZ' = F'(ZZ)
FZ" = F"(ZZ)
IDNT
=1
697
=2
901
=4
265
ISTRT
=1
=3
=2
364
XX=FZ
ISTRT
* 670
271
=2
364
XPLOT= XX* FINTX+XORIG
* 269
273

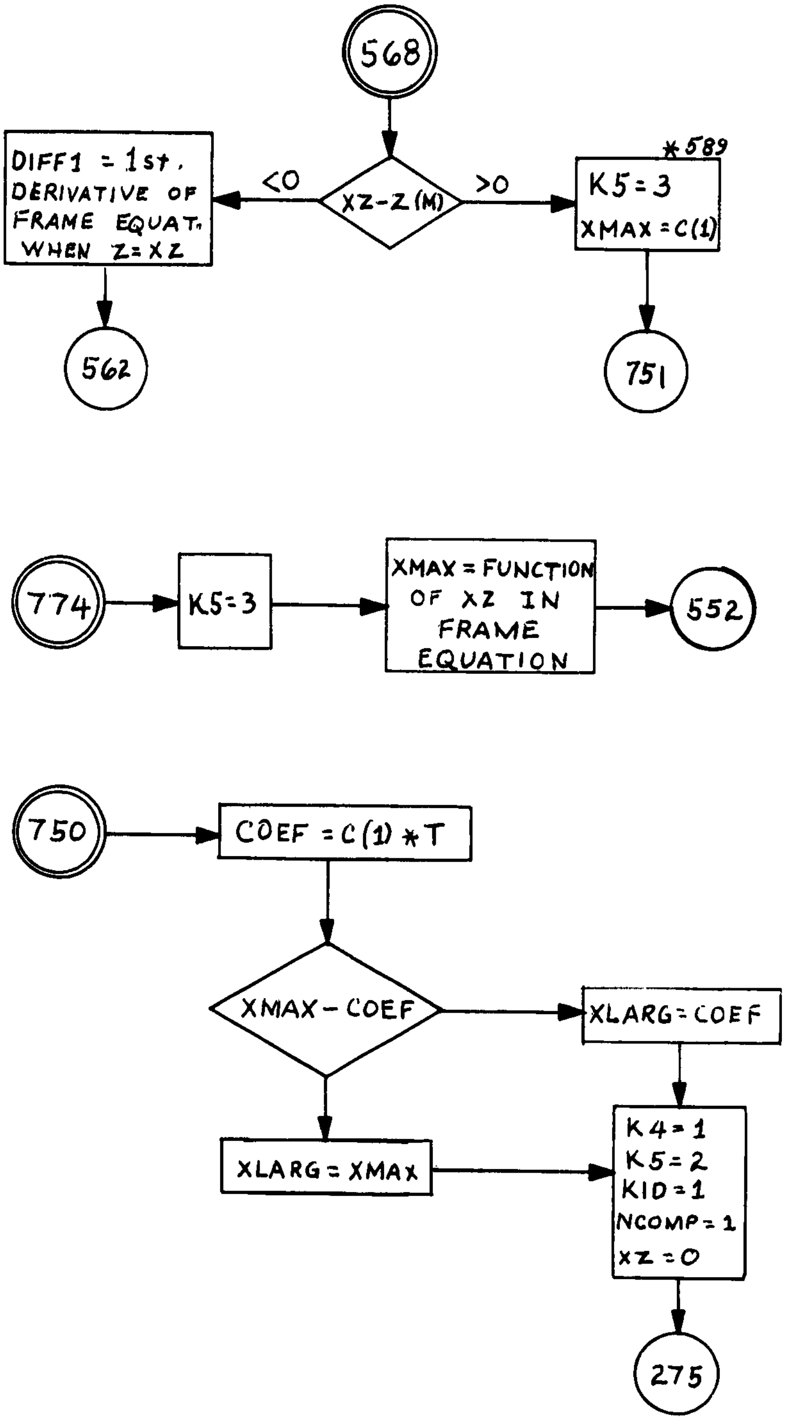

310
CALCULATE OFFSETS FOR STATIONS
READ ZT
FINT = FINTZ
SEG = SEGZ / FINTZ
RORIG = ZORIG
TOT = TOTZ
XX = ZT-XORIG / FINTX
566

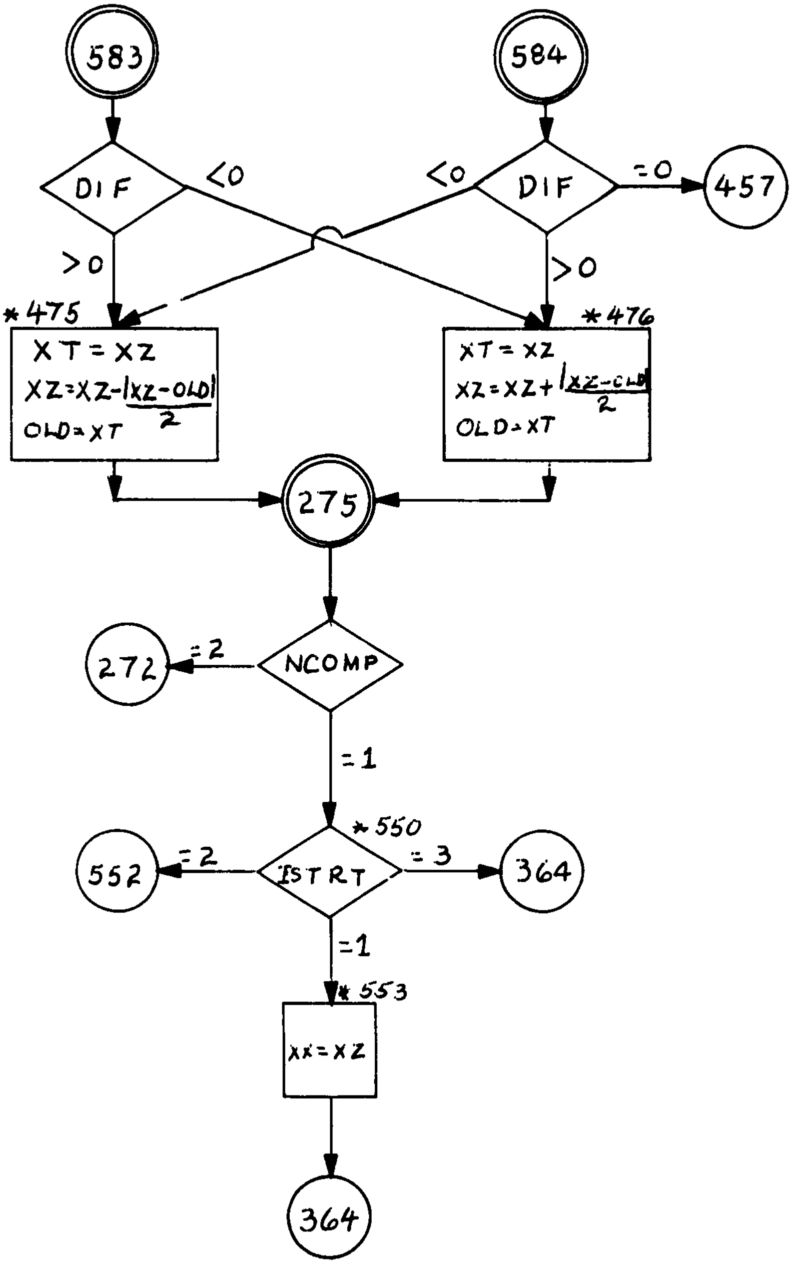

566
PATH FOR CALCULATIONS ON BULBOUS BOWS
NBOW
*597
=1
=2
ISTRT
*596
=3
≤2
XMAX=CZ(1)
ZMAX=ZORIG
XLARG=CZ(1)
567
*589
K5=3
XMAX=C(1)
751
SEGVA = (ZP(2)-ZP(1))/2
ISTRT
≤2
568
557
=3
*671
XZ-Z(M)
>0
596
DIFF1=1ST. DERIVATIVE OF PROFILE EQUAT FOR Z=XZ
557
OLD=XZ
XZ=XZ+SEGVA
555
≥0
*724
KID=2
<0
DIFF1
=3
ISTRT
*564
=1
KID
562
724
=1
=2
=2
690
=2
*779
FZ=XX
IND=2
=1
IND
364
*725
ZZ=XZ
=1
=2
*565
ISTRT
=3
726

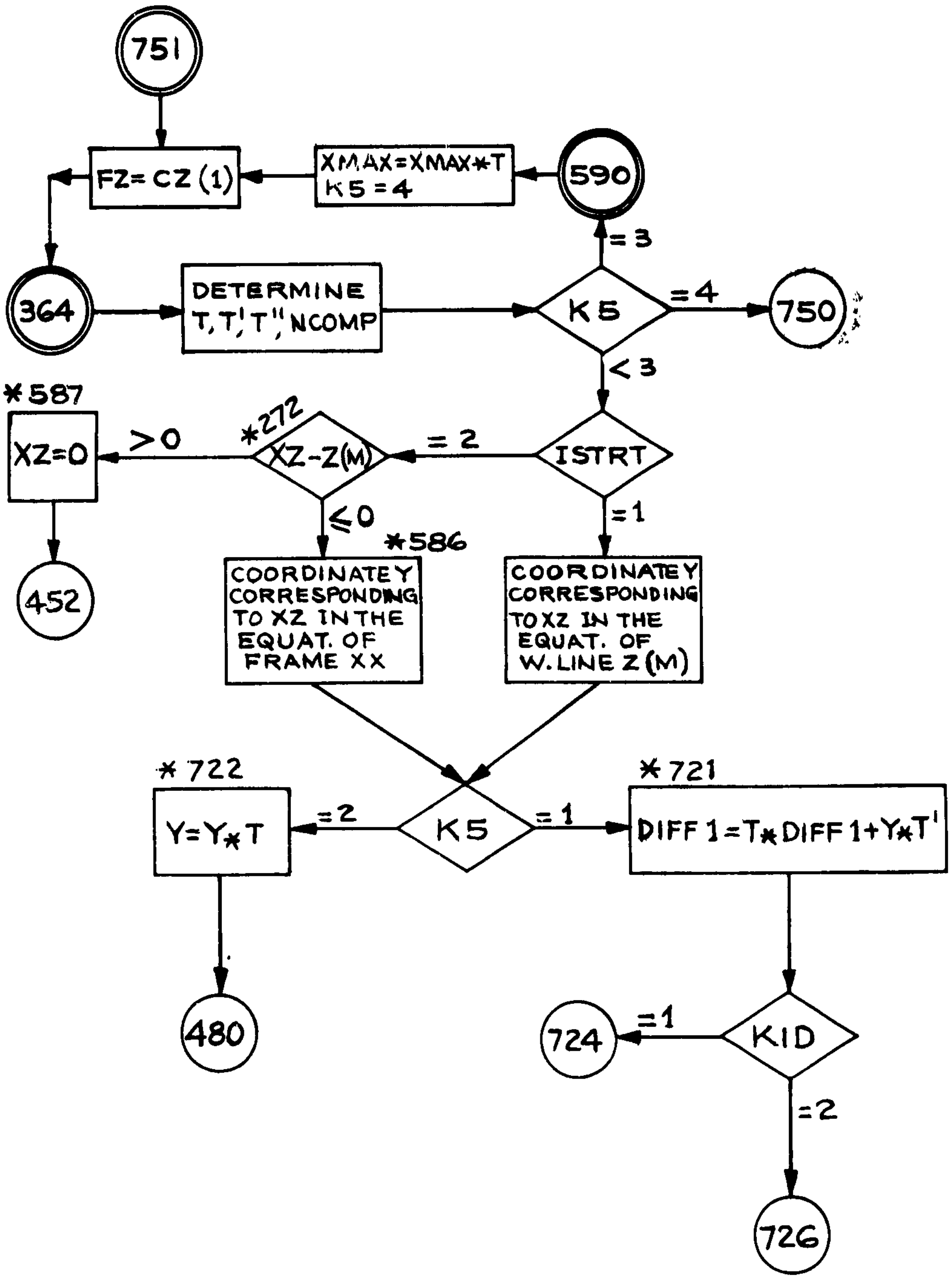

726
560
≤0
|DIFF1/FINTZ| -.00001
>0
*782
|OLD-XZ| - .001/FINTZ
≤0
560
555
=1
>0
*783
*559
SEGVA=OLD1-XZ
OLD=XZ
=2
K4
<0
DIFF1
=0
560
*558
>0
*561
XZ=XZ+SEGVA/2
SEGVA=OLD-XZ
OLD1=XZ
K4=2
557


560
ZMAX=XZ*FINTZ+ZORIG
ISTRT
=1
=2
*774
K5=3
=3
*775
XMAX=FUNCTION OF XZ IN PROFILE EQUATION
XMAX=FUNCTION OF XZ IN FRAME EQUATION
*577
XMAX-CZ(1)
≤0
XLARG=CZ(1)
>0
XLARG=XMAX
552
567
XGREA=XLARG
K4=1
K5=2
KID=1
ZZ=XZ
IDNT
<4
*795
XZ=0
PATH FOR CALCULATING OFFSETS ON EITHER WATERLINES OR STATIONS
360
=4
690
=0
*794
BUTTOCK
≠0
ISTRT
=2
=1
212
=3
ISTRT=1

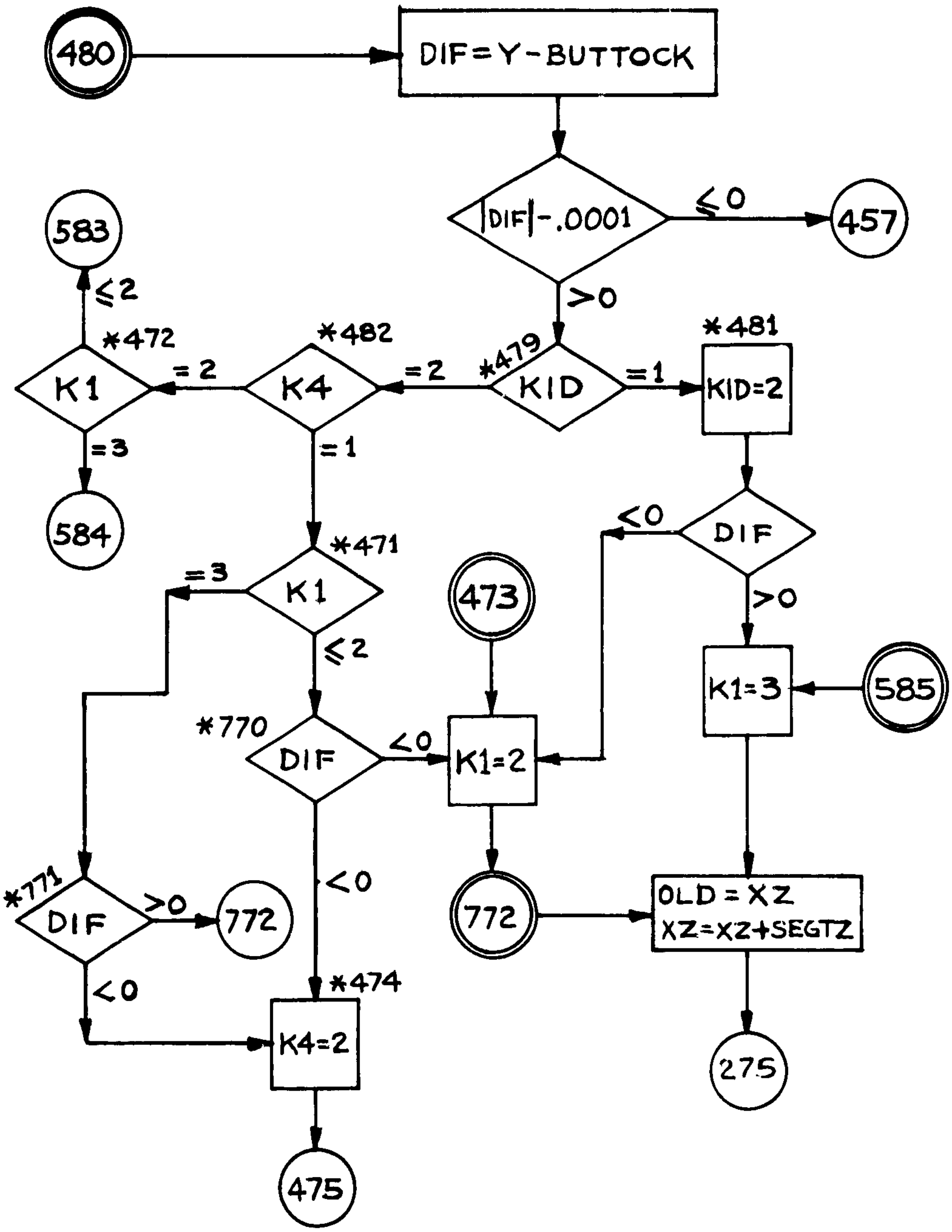

60
K3
=1
*61
PUNCH PEN DOWN
=0
*460
XX= XX+ SEG
K3=0
XX-(GREA+POINT)
≥0
NCOMP=2
NCOMP=1
XZ=0
NUMBER=1
IND=1
K4=1
KID=1
K1=1
CALCULATE COEFFICIENTS OF THE EQUAT FOR FRAM XX
C(I)
360
≤2
ISTRT
=3
226
268
<0
*723
K5=1
XX-CZ(1)
=0
IDNT
<4
798
=4
566
>0
*797
IDNT
<4
552
IND=2
566


568
XZ-Z(M)
<0
>0
DIFF1 = 1st. DERIVATIVE OF FRAME EQUATn WHEN Z=XZ
*589
K5=3
XMAX=C(1)
562
751
774
K5=3
XMAX = FUNCTION OF XZ IN FRAME EQUATION
552
750
COEF = C(1) * T
XMAX - COEF
XLARG = COEF
XLARG = XMAX
K4=1
K5=2
KID=1
NCOMP=1
XZ=0
275

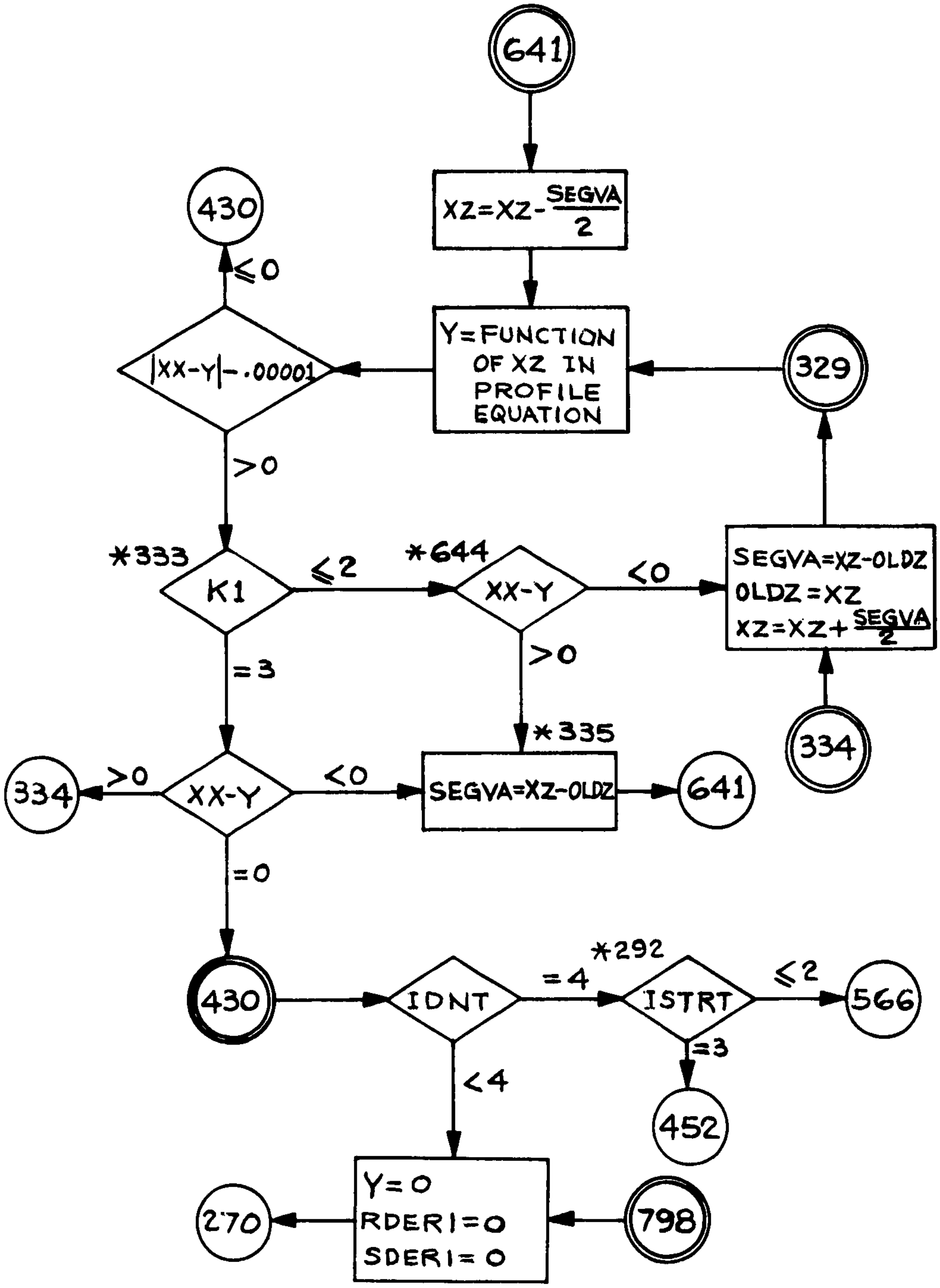

583
584
DIF
<0
>0
DIF
<0
=0
457
>0
*475
XT = XZ
XZ=XZ-|XZ-OLD|/2
OLD=XT
*476
XT = XZ
XZ=XZ+|XZ-OLD|/2
OLD=XT
275
272
=2
NCOMP
=1
*550
552
=2
ISTRT
=3
364
=1
*553
XX=XZ
364

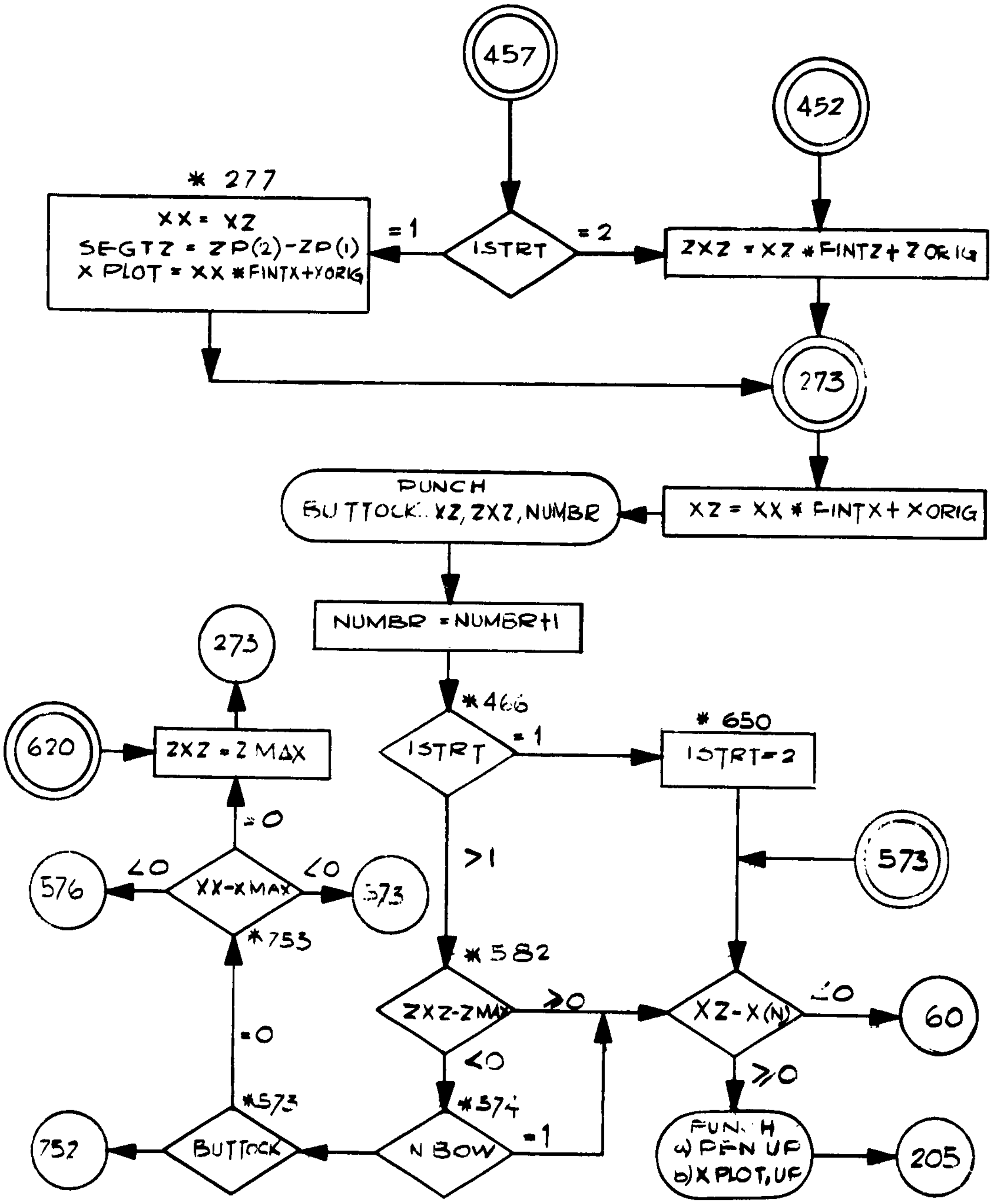


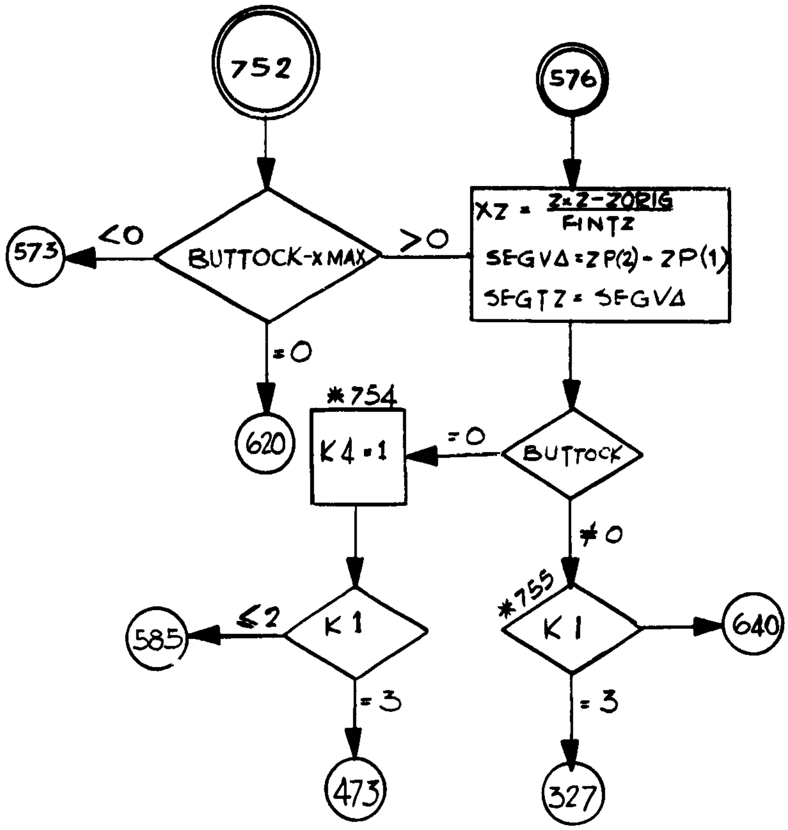
* ACTUAL FORTRAN NUMBER

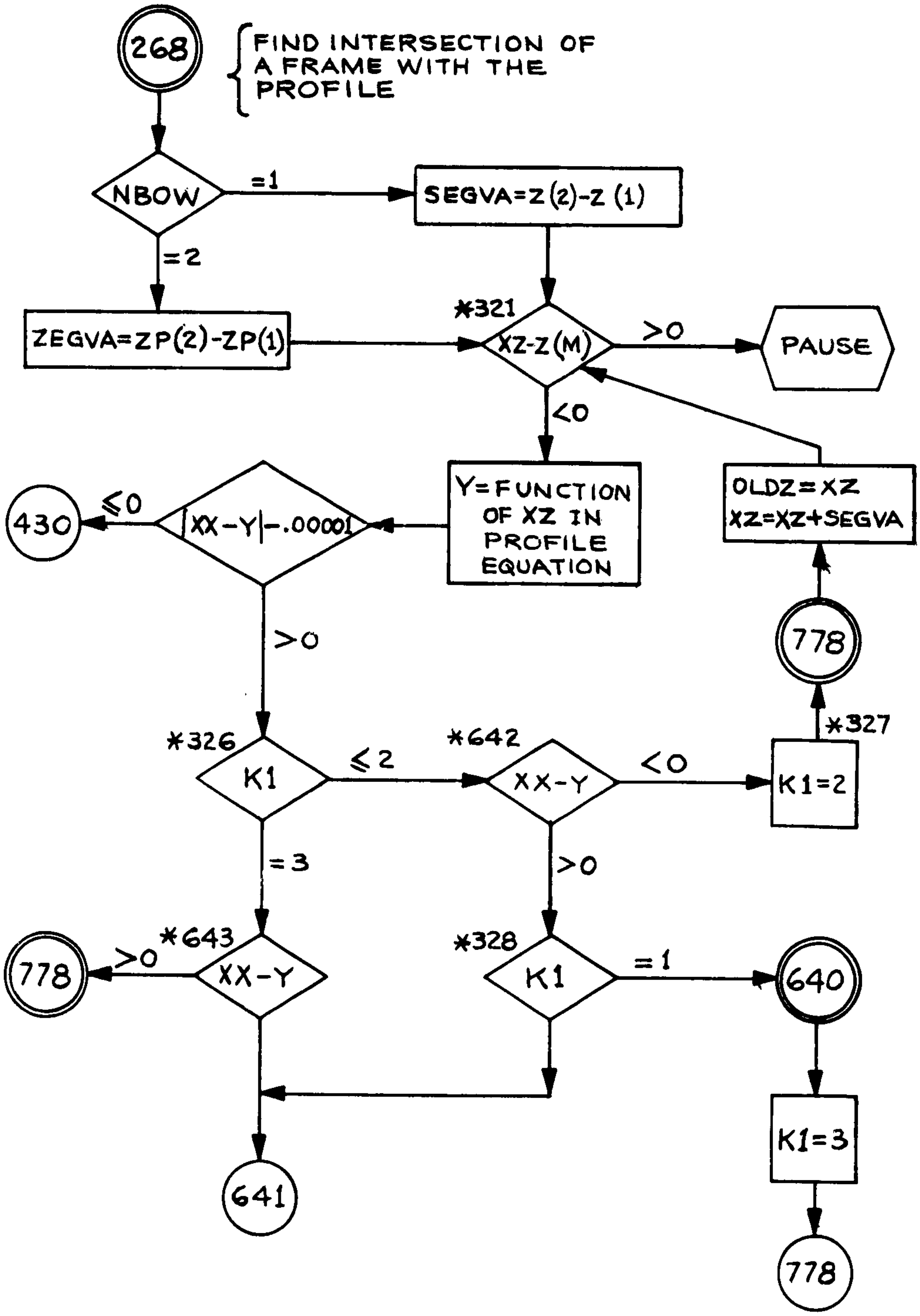


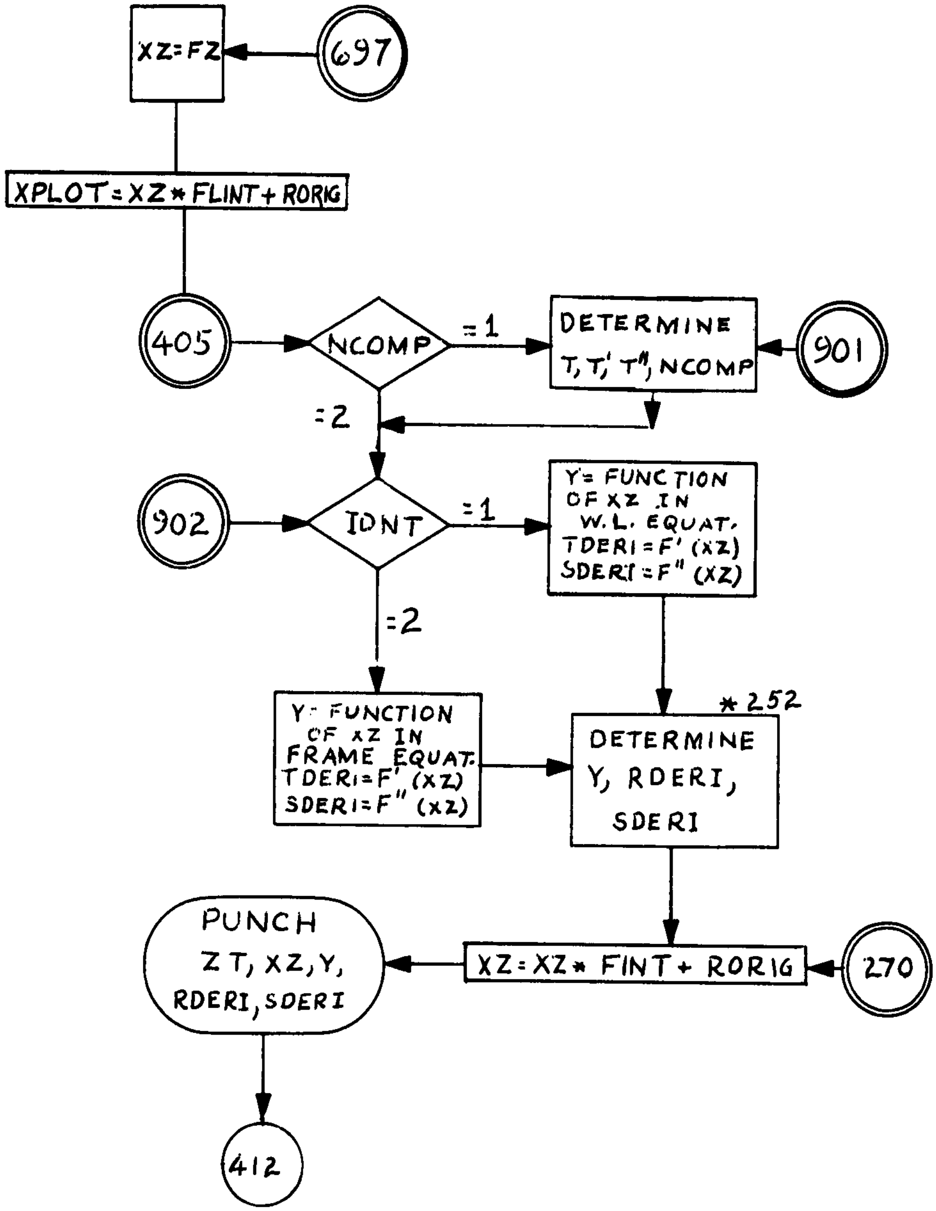
* ACTUAL FORTRAN NUMBER

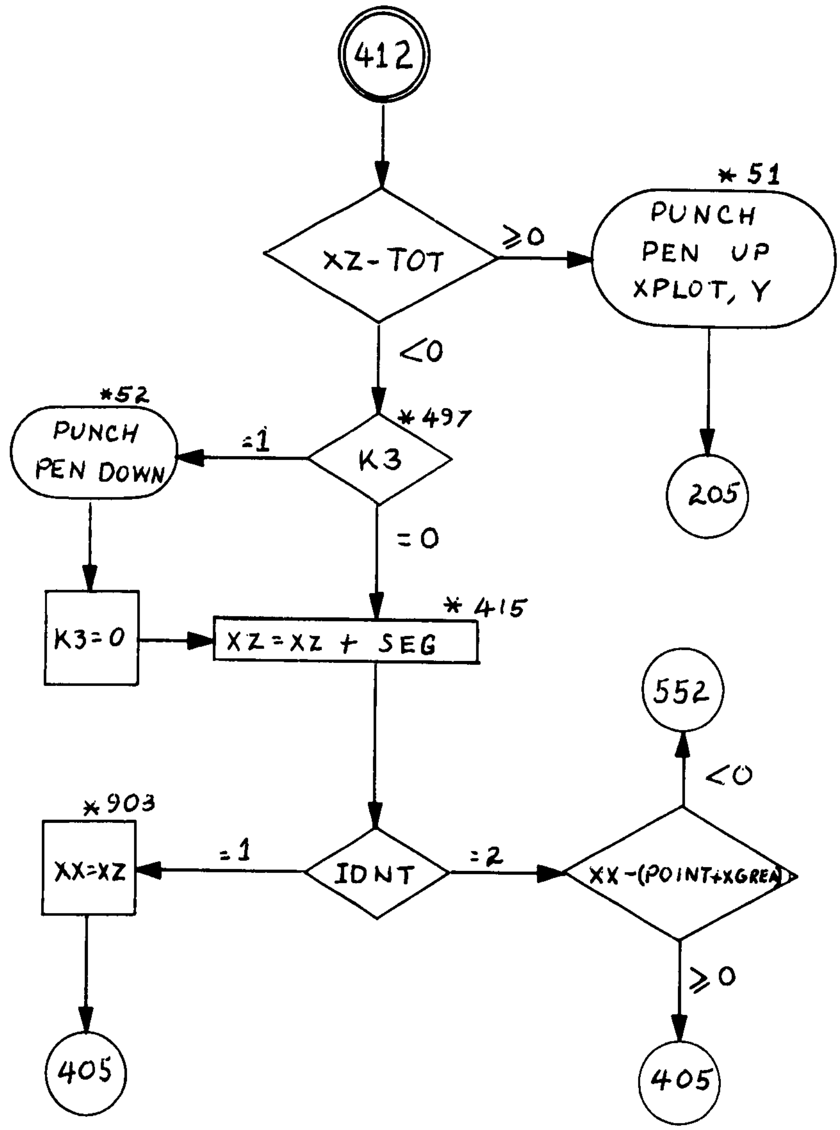

641
XZ=XZ-SEGVA/2
430
≤0
Y=FUNCTION OF XZ IN PROFILE EQUATION
329
|XX-Y|-.00001
>0
*333
K1
≤2
*644
XX-Y
<0
SEGVA=XZ-OLDZ
OLDZ=XZ
XZ=XZ+SEGVA/2
>0
=3
*335
334
334
>0
XX-Y
<0
SEGVA=XZ-OLDZ
641
=0
*292
430
IDNT
=4
ISTRT
≤2
566
=3
<4
452
Y=0
RDER1=0
SDER1=0
270
798


457
452
* 277
XX = XZ
SEGTZ = ZP(2)-ZP(1)
X PLOT = XX * FINTX+YORIG
=1
ISTRT
=2
ZXZ = XZ * FINTZ + ZORIG
273
PUNCH
BUTTOCK: XZ, ZXZ, NUMBR
XZ = XX * FINTX + XORIG
NUMBR = NUMBR+1
273
*466
ISTRT
=1
* 650
ISTRT=2
620
ZXZ = ZMAX
=0
>1
573
576
<0
XX-XMAX
<0
573
*753
*582
ZXZ-ZMAX
≥0
XZ-X(N)
<0
60
=0
<0
≥0
*573
*574
752
BUTTOCK
N BOW
=1
PUNCH
a) PEN UP
b) X PLOT, UP
205


752
576
573
<0
BUTTOCK-XMAX
>0
XZ = Z*Z-ZORIG / FINTZ
SEGVΔ=ZP(2)-ZP(1)
SEGTZ=SEGVΔ
=0
620
*754
K4=1
=0
BUTTOCK
≠0
585
≤2
K1
*755
K1
640
=3
473
=3
327


268
FIND INTERSECTION OF A FRAME WITH THE PROFILE
NBOW
=1
SEGVA=Z(2)-Z(1)
=2
ZEGVA=ZP(2)-ZP(1)
*321
XZ-Z(M)
>0
PAUSE
<0
Y=FUNCTION OF XZ IN PROFILE EQUATION
OLDZ=XZ
XZ=XZ+SEGVA
430
≤0
|XX-Y|-.00001
>0
778
*326
K1
≤2
*642
XX-Y
<0
K1=2
*327
=3
>0
*643
XX-Y
>0
778
*328
K1
=1
640
K1=3
778
641


XZ=FZ
697
XPLOT=XZ*FLINT+RORIG
405
NCOMP
=1
DETERMINE
T, T', T'', NCOMP
901
=2
902
IDNT
=1
Y= FUNCTION
OF XZ IN
W.L. EQUAT.
TDERI=F' (XZ)
SDERI=F'' (XZ)
=2
Y= FUNCTION
OF XZ IN
FRAME EQUAT.
TDERI=F' (XZ)
SDERI=F'' (XZ)
*252
DETERMINE
Y, RDERI,
SDERI
PUNCH
ZT, XZ, Y,
RDERI, SDERI
XZ=XZ*FINT+RORIG
270
412


412
XZ-TOT
≥0
*51
PUNCH
PEN UP
XPLOT, Y
205
<0
*52
PUNCH
PEN DOWN
=1
*497
K3
=0
K3=0
*415
XZ=XZ + SEG
552
<0
*903
XX=XZ
=1
IDNT
=2
XX-(POINT+XGREAT)
≥0
405
405

GOBACK 2 - WITH PROFILE

D. LISTING

```
*1205
C       SURFACE GO BACK  PROFILE
        DIMENSION X(15),A(13,17),Z(11),C(18),CZ(16),ZX(15),ZP(11)
   100 READ 123
        PUNCH 123
        READ 101,XORIG,ZORIG,FINTX,FINTZ,M,N,K,NAB
        READ 102, SEGX,SEGZ,POINT,PWR1,PWR2,NBOW
        POINT=(POINT-XORIG)/FINTX
        NP=N+2
        MP=M+2
        DO 206 I=1,K
        READ 102,CZ(I)
   206 CONTINUE
        FIVE=5000.
        SIX=6000.
        DO 305 I=1,MP
        DO 202 J=1,NP
   202 READ 102, A(I,J)
   305 CONTINUE
        M=MP-3
        N=NP-3
        DO 203 I=1,M
        READ 102,Z(I)
        IF(M-I)230,232,203
   232 TOTZ=Z(I)
   203 Z(I)=(Z(I)-ZORIG)/FINTZ
   230 DO 204 I=1,N
        READ 102,X(I)
        IF(N-I)340,233,204
   233 TOTX=X(I)
   204 X(I)=(X(I)-XORIG)/FINTX
   340 IF(NAB)341,341,343
   341 KS=K-3
        DO 342 I=1,KS
        READ 102,ZP(I)
   342 ZP(I)=(ZP(I)-ZORIG)/FINTZ
        GO TO 205
   343 KS=M
        DO 344 I=1,M
   344 ZP(I)=Z(I)
   205 READ 106,IDNT
        K1=1
```

```
      NUMBR=1
      ISTRT=3
      K2=0
      K3=1
      K4=1
      K5=1
      KSR=KS
      KID=1
      XZ=0.
      IND=1
      OLD=0.
      NCOMP=1
      IF(IDNT-1)600,209,600
  600 IF(IDNT-2)601,310,601
  601 IF(IDNT-3)205,205,234
C POINT ON THE PROFILE CORRESPONDING TO W. L. ZZ
  690 CALL FUNCT1 (CZ(1),CZ(2),CZ(3),CZ(4),ZZ,FZ)
      FUPZ=CZ(2)+2.*ZZ*CZ(3)+3.*CZ(4)*ZZ*ZZ
      FUSZ=2.*CZ(3)+6.*CZ(4)*ZZ
      IF(ZZ-ZP(1))179,179,691
  691 DO 700 I=1,KS
      DIF=ZZ-ZP(I)
      IF(DIF-.0000001)179,179,720
  720 FUPZ=FUPZ+3.*CZ(I+4)*DIF*DIF
      FUSZ=FUSZ+6.*CZ(I+4)*DIF
  700 CALL FUNCT2 (FZ,CZ(I+4),DIF,FZ)
  179 GO TO (697,405,265,265),IDNT
  697 XX=FZ
      XZ=FZ
      GO TO 77
C  EQUATION OF W.L. ZZ
  212 DO 213 I=1,NP
      CALL FUNCT1 (A(1,I),A(2,I),A(3,I),A(4,I),ZZ,C(I))
  213 CONTINUE
      IF(ZZ-Z(1))216,216,215
  215 DO 218 I=1,NP
      DO 219 J=5,MP
      DIF=ZZ-Z(J-4)
      IF(DIF-.00000001)218,218,82
  82  CALL FUNCT2 (C(I),A(J,I),DIF,C(I))
  219 CONTINUE
  218 CONTINUE
  216 IF(IDNT-4)75,690,690
  75  DO 76 I=1,NP
  76  PUNCH 101,C(I)
      PUNCH 115
      GO TO 690
C  POINT ON THE PROFILE CORRESPONDING TO FRAME XX
  268 GO TO (571,572,572),NBOW
  572 SEGVA=ZP(2)-ZP(1)
```

```
      GO TO 321
  571 SEGVA=Z(2)-Z(1)
  321 IF(XZ-Z(M))581,581,580
  580 PAUSE 1
  581 CALL FUNCT1 (CZ(1),CZ(2),CZ(3),CZ(4),XZ,Y)
      IF(XZ-ZP(1))322,322,300
  300 DO 323 I=1,KS
      DIF=XZ-ZP(I)
      IF(DIF-.0000001)322,322,323
  323 CALL FUNCT2 (Y,CZ(I+4),DIF,Y)
  322 DIF=XX-Y
      IF(ABSF(DIF)-.00001)430,430,326
  326 GO TO (642,642,643),K1
  643 IF(DIF)641,430,778
  642 IF(DIF)327,430,328
  327 K1=2
  778 OLDZ=XZ
      XZ=XZ+SEGVA
      GO TO 321
  328 GO TO (640,641),K1
  640 K1=3
      GO TO 778
  641 XZ=XZ-SEGVA/2.
  329 CALL FUNCT1 (CZ(1),CZ(2),CZ(3),CZ(4),XZ,Y)
      IF(XZ-ZP(1))330,330,331
  331 DO 332 I=1,KS
      DIF=XZ-ZP(I)
      IF(DIF-.0000001)330,330,332
  332 CALL FUNCT2 (Y,CZ(I+4),DIF,Y)
  330 DIF=XX-Y
      IF(ABSF(DIF)-.00001)430,430,333
  333 GO TO (644,644,645),K1
  645 IF(DIF)335,430,334
  644 IF(DIF)334,430,335
  334 SEGVA=XZ-OLDZ
      OLDZ=XZ
      XZ=XZ+SEGVA/2.
      GO TO 329
  335 SEGVA=XZ-OLDZ
      GO TO 641
  430 IF(IDNT-3) 85,292,292
  85  DO 84 I=1,M
      K2=I-1
      IF (XZ-Z(I))798,84,84
  84  CONTINUE
  798 Y=0.
      RDERI=0.
      SDERI=0.
      GO TO 270
  292 GO TO (566,566,452),ISTRT
```

```
C  EQUATION OF FRAME XX
  360 DO 313 I=1,MP
  313 CALL FUNCT1 (A(I,1),A(I,2),A(I,3),A(I,4),XX,C(I))
      IF(XX-X(1))902,902,315
  315 DO 318 I=1,MP
      DO 319 J=5,NP
      DIF=XX-X(J-4)
      IF(DIF-.00000001)318,318,83
  83  CALL FUNCT2 (C(I),A(I,J),DIF,C(I))
  319 CONTINUE
  318 CONTINUE
  902 K5=1
      IF(IDNT-4)78,79,79
  78  DO 80 I=1,MP
  80  PUNCH 101,C(I)
      PUNCH 105
  79  IF(XX-CZ(1))268,796,797
  796 IF(IDNT-4)798,566,566
  797 IF(IDNT-4)552,780,780
  780 IND=2
      GO TO 566
C     * * D) OFFSETS OF A BUTTOCK * *
  234 SEG=SEGX/FINTX
      SGTZ=SEGZ/FINTZ
      ZXZ=TOTZ
      ZZ=Z(M)
      READ 102,BUTTK
      PUNCH 121
      IF(BUTTK)263,566,263
  263 DO 293 I=1,N
  293 ZX(I)=X(I)
      TOT=X(N)
      NM=N
      FUPZ=0
      FUSZ=0
      GO TO (621,597,597),NBOW
  621 XGREA=CZ(1)
      ISTRT=1
      GO TO 212
C  INTERSECTION OF BTK WITH A WL OR FR
  480 Y=Y-BUTTK
  453 IF(ABSF(Y)-.0001)457,457,479
  479 GO TO (481,482),KID
  481 KID=2
      IF(Y)473,457,585
  585 K1=3
      GO TO 772
  482 GO TO (471,472),K4
  471 GO TO (770,770,771),K1
  770 IF(Y)473,457,474
```

```
771 IF(Y)474,457,772
473 K1=2
772 OLD=XZ
    XZ=XZ+SEGTZ
    GO TO 275
474 K4=2
    GO TO 475
472 GO TO (583,583,584),K1
583 IF(Y)476,457,475
584 IF(Y)475,457,476
475 XT=XZ
    XZ=XZ-(ABSF(XZ-OLD))/2.
    OLD=XT
    GO TO 275
476 XT=XZ
    XZ=XZ+(ABSF(XZ-OLD))/2.
    OLD=XT
    GO TO 275
457 GO TO (277,452),ISTRT
452 ZXZ=XZ*FINTZ+ZORIG
273 XZ=XX*FINTX+XORIG
468 CALL PUNCH3 (BUTTK,XZ,ZXZ,NUMBR)
    NUMBR=NUMBR+1
466 GO TO (650,582,582),ISTRT
650 ISTRT=2
    GO TO 573
582 IF(ZXZ-ZMAX)574,573,573
574 GO TO (573,575,575),NBOW
575 IF(BUTTK)752,753,752
752 IF(BUTTK-XMAX)573,620,576
753 IF(XX-XMAX)576,620,573
576 XZ=(ZXZ-ZORIG)/FINTZ
    SEGVA=ZP(2)-ZP(1)
    SEGTZ=SEGVA
    IF(BUTTK)754,755,754
754 K4=1
    GO TO (585,585,473),K1
755 GO TO (640,640,327),K1
C  CHECK FOR LAST VALUE
573 IF(XZ-TOTX)60,64,64
64  PUNCH 110,SIX
 65 CALL PUNCH2 (XPLOT,ZXZ)
    GO TO 205
60  IF(K3)61,460,61
61  PUNCH 108,FIVE
    K3=0
460 IF(XX+SEG-X(K2+1))463,461,461
461 K2=K2+1
    XX=X(K2)
324 XZ=0.
```

```
      NUMBR=1
      IND=1
C  CHECK FOR FR OUTSIDE OF AREA WHERE FUNCT. T IS DEFINED
      IF(XX-POINT-XGREA)674,675,675
  675 NCOMP=2
      GO TO 673
  674 NCOMP=1
  673 K4=1
      KID=1
      K1=1
      GO TO (360,360,266),ISTRT
  463 XX=XX+SEG
      GO TO 324
C  FUNCT. T AND ITS 1ST AND 2ND DERIV
  364 CALL PROFL2 (XX,FZ,PWR1,FUPZ,FUSZ,PWR2,POINT,T,TP,TS,NCOMP)
      IF(K5-3)272,590,750
  272 IF(XZ-TOT)586,586,587
  587 XZ=0.
      GO TO 452
  586 CALL FUNCT1(C(1),C(2),C(3),C(4),XZ,Y)
      IF(XZ-ZX(1))368,368,369
  369 DO 346 I=1,NM
      DIF=XZ-ZX(I)
      IF(DIF-.000001)368,368,346
  346 CALL FUNCT2 (Y,C(I+4),DIF,Y)
  368 GO TO (721,722),K5
  721 DIFF1=T*DIFF1+Y*TP
      GO TO (724,726),KID
  722 Y=Y*T
      GO TO 480
  265 GO TO (670,364,670),ISTRT
  670 XX=FZ
  301 GO TO (271,364,269),ISTRT
  269 XPLOT=XX*FINTX+XORIG
      GO TO 273
  266 IF(XX-XLARG)268,267,267
  267 GO TO (275,275,291),ISTRT
  291 ZXZ=ZORIG
      GO TO 273
  271 XZ=XX
      SEGTZ=SEG
  275 GO TO (550,272),NCOMP
  550 GO TO (553,552,364),ISTRT
  552 ZZ=XZ
      GO TO 690
  277 DO 294 I=1,M
  294 ZX(I)=Z(I)
      TOT=Z(M)
```

```
      NM=M
      XX=XZ
      SEGTZ=ZP(2)-ZP(1)
      XPLOT=XX*FINTX+XORIG
   77 DO 370 I=1,N
      K2=I-1
      IF(XX-X(I)) 81,370,370
  370 CONTINUE
   81 IF(IDNT-4)901,273,273
  553 XX=XZ
      GO TO 364
C  DETERMINE THE PT WHERE 1ST DERIV. CHANGES FROM - TO + IN
C  THE PROFILE OR FRAME EQUATIONS
  566 GO TO (596,597,597),NBOW
  596 GO TO (589,589,598),ISTRT
  598 XMAX=CZ(1)
      ZMAX=ZORIG
      XLARG=CZ(1)
      GO TO 567
  597 SEGVA=(ZP(2)-ZP(1))/2.
  557 GO TO (568,568,671),ISTRT
  671 IF(XZ-Z(M))710,710,596
  710 DIFF1=CZ(2)+2.*CZ(3)*XZ+3.*CZ(4)*XZ*XZ
      IF(XZ-ZP(1))562,562,551
  551 DO 563 I=1,KS
      DIF=XZ-ZP(I)
      IF(DIF-.0000001)562,562,563
  563 DIFF1=DIFF1+3.*CZ(I+4)*DIF*DIF
  562 GO TO (564,565),KID
  564 GO TO (725,725,724),ISTRT
  724 IF(DIFF1)556,555,555
  555 OLD=XZ
      XZ=XZ+SEGVA
      GO TO 557
  556 KID=2
      GO TO 555
  565 GO TO (725,725,726),ISTRT
  725 ZZ=XZ
      GO TO (779,690),IND
  779 FZ=XX
      IND=2
      GO TO 364
  726 IF(ABSF(DIFF1/FINTZ)-.00001)560,560,782
  782 IF(ABSF(OLD-XZ)-.001/FINTZ)560,560,783
  783 IF(DIFF1)558,560,561
  558 GO TO (555,559),K4
  568 IF(XZ-Z(M))588,588,589
  588 DIFF1=C(2)+2.*C(3)*XZ+3.*C(4)*XZ*XZ
      IF(XZ-Z(1))562,562,776
  776 DO 777 I=1,M
```

```
      DIF=XZ-Z(I)
      IF(DIF-.0000001)562,562,777
  777 DIFF1=DIFF1+3.*C(I+4)*DIF*DIF
      GO TO 562
  589 K5=3
      XMAX=C(1)
      GO TO 751
  774 K5=3
      CALL FUNCT1(C(1),C(2),C(3),C(4),XZ,XMAX)
      IF(XZ-Z(1))552,552,591
  591 DO 592 I=1,M
      DIF=XZ-Z(I)
      IF(DIF-.0000001)552,552,592
  592 CALL FUNCT2(XMAX,C(I+4),DIF,XMAX)
      GO TO 552
  590 XMAX=XMAX*T
      K5=4
  751 FZ=CZ(1)
      GO TO 364
  750 COEF=C(1)*T
      IF(XMAX-COEF)594,593,593
  593 XLARG=COEF
      GO TO 595
  594 XLARG=XMAX
  595 K4=1
      K5=2
      KID=1
      NCOMP=1
      XZ=0.
      GO TO 275
  559 SEGVA=OLD1-XZ
      OLD=XZ
      XZ=XZ+SEGVA/2.
      GO TO 557
  561 K4=2
      SEGVA=XZ-OLD
      OLD1=XZ
      XZ=XZ-SEGVA/2.
      GO TO 557
  560 ZMAX=XZ*FINTZ+ZORIG
      GO TO (774,774,775),ISTRT
  775 CALL FUNCT1(CZ(1),CZ(2),CZ(3),CZ(4),XZ,XMAX)
      IF(XZ-ZP(1))577,577,569
  569 DO 570 I=1,KS
      DIF=XZ-ZP(I)
      IF(DIF-.0000001)577,577,570
  570 CALL FUNCT2 (XMAX,CZ(I+4),DIF,XMAX)
  577 IF(XMAX-CZ(1))578,578,579
  578 XLARG=CZ(1)
      GO TO 567
```

```
 579 XLARG=XMAX
 567 K4=1
     K5=2
     KID=1
     XGREA=XLARG
     IF(IDNT-4)795,794,795
 795 XZ=0.
     GO TO 360
 794 IF(BUTTK)622,690,622
 622 GO TO (212,690,623),ISTRT
 623 ISTRT=1
     GO TO 212
 620 ZXZ=ZMAX
     GO TO 273
C    * * A) OFFSETS OF A WATER LINE * *
 209 READ 102,ZT
     FINT=FINTX
     SEG=SEGX/FINTX
     RORIG=XORIG
     TOT=TOTX
     DO 236 I=1,N
 236 ZX(I)=X(I)
     ZZ=(ZT-ZORIG)/FINTZ
     GO TO 212
 405 GO TO (901,70),NCOMP
C  FUNCT. T AND ITS 1ST AND 2ND DERIV
 901 CALL PROFL2 (XX,FZ,PWR1,FUPZ,FUSZ,PWR2,POINT,T,TP,TS,NCOMP)
  70 Y=C(1)+C(2)*XZ+C(3)*XZ*XZ+C(4)*XZ**3
     TDERI=C(2)+C(3)*2.*XZ+C(4)*3.*XZ*XZ
     SDERI=C(3)*2.+C(4)*6.*XZ
     IF(K2-1)406,408,408
 408 DO 409 I=1,K2
     DIF=XZ-ZX(I)
     IF(ABSF(DIF)-.00000001)409,409,252
 252 PRODCT=C(I+4)*DIF
     Y=Y+PRODCT*DIF*DIF
     TDERI=TDERI+3.*PRODCT*DIF
     SDERI=SDERI+6.*PRODCT
     IF(I-K2)409,406,406
 409 CONTINUE
 406 RDERI=(TDERI*T+Y*TP)/FINT
     SDERI=(SDERI*T+2.*TDERI*TP+Y*TS)/(FINT*FINT)
     Y=Y*T
 270 ZXZ=XZ*FINT+RORIG
     CALL PUNCH1 (ZT,ZXZ,Y,RDERI,SDERI,IDNT)
 412 IF(ZXZ-TOT)497,51,51
 51  PUNCH 110,SIX
     CALL PUNCH2 (XPLOT,Y)
     GO TO 205
```

```
  497 IF(K3)52,415,52
  52  PUNCH 108,FIVE
      XPLOT=ZXZ
      K3=0
  415 IF(XZ+SEG-ZX(K2+1))416,501,501
  501 K2=K2+1
      XZ=ZX(K2)
      GO TO 432
  416 XZ=XZ +SEG
  432 GO TO (903,799),IDNT
  799 IF(XX-POINT-XGREA)552,405,405
  903 XX=XZ
      GO TO 405
C     * * B) OFFSETS OF A FRAME OR STATION * *
  310 READ 102,ZT
      FINT=FINTZ
      SEG=SEGZ/FINTZ
      RORIG=ZORIG
      TOT=TOTZ
      DO 401 I=1,M
  401 ZX(I)=Z(I)
      XX=(ZT-XORIG)/FINTX
      GO TO 566
  101 FORMAT(4F15.8,415)
  102 FORMAT(5F15.8,I5)
  104 FORMAT(2F15.8,I5)
  105 FORMAT(7H IDENT.,9X,1HZ,17X,1HY,11X,10HFIRST DER.,4X,11HSECOND
DER
     C.)
  106 FORMAT(I4,F15.8)
  107 FORMAT(2HWL,F7.2,F14.8,3X,3F15.8)
  108 FORMAT(8HPEN DOWN,F15.8)
  109 FORMAT(2HFR,F7.2,F14.8,3X,3F15.8)
  110 FORMAT(6HPEN UP,2X,F15.8)
  111 FORMAT(2HLG,I3,3X,F15.8,3X,F15.8)
  112 FORMAT(7H IDENT.,9X,1HZ,17X,1HY,12X,9HTOLERANCE)
  113 FORMAT(7H IDENT.,9X,1HX,17X,1HY,12X,9HTOLERANCE)
  114 FORMAT(2HDP,F6.2,F15.8,3X,2F15.8)
  115 FORMAT(7H IDENT.,9X,1HX,17X,1HY,11X,10HFIRST DER.,4X,11HSECOND
DER
     C.)
  116 FORMAT(1X,6HIDENT.,9X,1HX,17X,1HY,7X,14HFIRST DERIVAT.)
  117 FORMAT(1X,6HIDENT.,10X,1HX,17X,1HY,14X,1HZ)
  118 FORMAT(1X,6HIDENT.,9X,1HZ,17X,1HY,7X,14HFIRST DERIVAT.)
  120 FORMAT(7X,1HA,13X,1HB,13X,1HC,13X,1HD,9X,5HSTART,8H FINISH)
  121 FORMAT(7H IDENT.,10X,1HX,17X,1HZ)
  122 FORMAT(4F14.8,2F8.3)
  123 FORMAT(50H                                                  )
  124 FORMAT(25H                         )
```

```
  125 FORMAT(8X,1HX,14X,1HZ,14X,1HY)
      END
*1205
      SUBROUTINE PROFL2(XD,FD,EXPD1,TZPD,TZSD,EXPD2,X1,TD,TPD,TSD,NCD
)
      TD=(X1+FD-XD)/X1
      IF(TD-.00001)1,1,2
    2 DIFD=EXPD1-1.
      PROD=TD**DIFD
      TPD1=EXPD1*TZPD*PROD
      TSD1=EXPD1*(DIFD*TD**(DIFD-1.)*TZPD**2+TZSD*PROD)
      TD=1.-TD**EXPD1
      IF(TD-.00001)7,7,4
    4 DIFD=EXPD2-1.
      TDEXP=TD**DIFD
      TPD=-EXPD2*TPD1*TDEXP
      TSD=EXPD2*(DIFD*TD**(EXPD2-2.)*TPD1*TPD1-TSD1*TDEXP)
      TD=TD**EXPD2
      IF(TD-.00001)7,7,6
    7 TD=0.
      GO TO 3
    6 NCD=1
      RETURN
    1 NCD=2
      TD=1.
    5 TPD=0.
      TSD=0.
      RETURN
    3 NCD=1
      GO TO 5
      END
*1205
      SUBROUTINE PUNCH1 (ZD,XID,YID,RD,SD,ID)
      XD=XID
      YD=YID
      IF(XD)1,2,2
    1 XD=-XD
      IF(YD)3,4,4
    2 IF(YD)5,6,6
    5 YD=-YD
      GO TO (7,8),ID
    7 PUNCH 20,ZD,XD,YD,RD,SD
      RETURN
    8 PUNCH 21,ZD,XD,YD,RD,SD
      RETURN
    6 GO TO (9,10),ID
    9 PUNCH 22,ZD,XD,YD,RD,SD
      RETURN
   10 PUNCH 23,ZD,XD,YD,RD,SD
      RETURN
    3 YD=-YD
```

```
      GO TO (11,12),ID
   11 PUNCH 24,ZD,XD,YD,RD,SD
      RETURN
   12 PUNCH 25,ZD,XD,YD,RD,SD
      RETURN
    4 GO TO (13,14),ID
   13 PUNCH 26,ZD,XD,YD,RD,SD
      RETURN
   14 PUNCH 27,ZD,XD,YD,RD,SD
      RETURN
   20 FORMAT(2HWL,F7.2,F14.8,4X,1H-,F13.8,2F15.8)
   21 FORMAT(2HFR,F7.2,F14.8,4X,1H-,F13.8,2F15.8)
   22 FORMAT(2HWL,F7.2,F14.8,3X,3F15.8)
   23 FORMAT(2HFR,F7.2,F14.8,3X,3F15.8)
   24 FORMAT(2HWL,F7.2,1H-,F13.8,4X,1H-,F13.8,2F15.8)
   25 FORMAT(2HFR,F7.2,1H-,F13.8,4X,1H-,F13.8,2F15.8)
   26 FORMAT(2HWL,F7.2,1H-,F13.8,3X,3F15.8)
   27 FORMAT(2HFR,F7.2,1H-,F13.8,3X,3F15.8)
      END
*1205
      SUBROUTINE PUNCH2 (XID,YID)
      XD=XID
      YD=YID
      IF(XD)1,2,2
    1 XD=-XD
      IF(YD)3,4,4
    2 IF(YD)5,6,6
    3 YD=-YD
      PUNCH 30,XD,YD
      RETURN
    4 PUNCH 31,XD,YD
      RETURN
    5 YD=-YD
      PUNCH 32,XD,YD
      RETURN
    6 PUNCH 33,XD,YD
      RETURN
   30 FORMAT (5HGO TO,4X,1H-,F13.8,4X,1H-,F13.8)
   31 FORMAT (5HGO TO,4X,1H-,F13.8,3X,F15.8)
   32 FORMAT (5HGO TO,4X,F14.8,4X,1H-,F13.8)
   33 FORMAT (5HGO TO,4X,F14.8,3X,F15.8)
      END
*1205
      SUBROUTINE PUNCH3 (BUTTK,XZ,ZXZ,NUMBR)
      IF (XZ) 1,2,2
    1 XZ4=-XZ
      PUNCH 126,BUTTK,XZ4,ZXZ,NUMBR
      RETURN
    2 PUNCH 119,BUTTK,XZ,ZXZ,NUMBR
```

```
      RETURN
  119 FORMAT(2HBK,F6.2,F15.8,3X,F15.8,6X,I2)
  126 FORMAT(2HBK,F6.2,2H -,F13.8,3X,F15.8,6X,I2)
      END
*1205
      SUBROUTINE FUNCT1(C1,C2,C3,C4,XD,YD)
      YD=C1+C2*XD+C3*XD*XD+C4*XD*XD*XD
      RETURN
      END
*1205
      SUBROUTINE FUNCT2 (YD1,C5,DIFD,YD2)
      YD2=YD1+C5*DIFD*DIFD*DIFD
      RETURN
      END
*1205
      SUBROUTINE DERIV1 (C2D,C3D,C4D,FXD,FZPD,FZSD)
      FZPD=C2D+2.*C3D*FXD+3.*C4D*FXD*FXD
      FZSD=2.*C3D+6.*C4D*FXD
      RETURN
      END
*1205
      SUBROUTINE DERIV2 (C5D,DIFD,FPD,FSD,FZPD,FZSD)
      PROD=3.*C5D*DIFD
      FZPD=FPD+PROD*DIFD
      FZSD=FSD+2.*PROD
      RETURN
      END
```

Section VII

GOBACK 3

A. OPERATING INSTRUCTIONS

This version of GOBACK will accept coefficients of two-dimensional curves, either single or double splined, as shown in Fig. D-1.

From these coefficients it will do the following:

(1) Calculate offsets

(2) Calculate first and second derivatives

(3) Plot a picture of the curve

The program is written in FORTRAN for the IBM-1620 computer. In order to plot the results, one of the subroutines of Appendix F must be included in the FORTRAN compiler and the hardware requirements of Appendix F must be met.

Fortran Symbol Definitions

Symbol		Definition
RORIG	-	The x coordinate of the first point on the full size curve
SEG	-	Interval between calculated offsets on the full size curve
CA	-	Value of the offset of the first point on the full size curve
N	-	Number of coefficients in the equation without the first coefficient
L	-	Number of offsets given in the data, except the first offset
K	-	Number of specific points where offsets must be calculated (0 if none required)

CX	-	Scale factor for plotting in the x direction on the curve (lengthwise on the plotter). x plotted equals x calculated times CX
CY	-	Scale factor for plotting in the y direction on the curve (crosswise on the plotter). y plotted equals y calculated times CY
FINT	-	The interval between the first two stations on the original curve (x_1-x_0)
A	-	The coefficients of the equation
XA	-	The x coordinates of the original data offsets (stations) from Station 2 to the last station
XE	-	List of x coordinates of specific points where offsets are to be calculated in order from least to greatest x value

Input Data Cards

The description of the cards given below is in terms of the actual FORTRAN format. The standard F field description - for fixed point decimal numbers, and the I field - for integer numbers which must always be right justified, are used. The fields given come consecutively across the card.

Card Formats

	Contents			Card No.
Format	F15.8	F15.8	F15.8	
Variable	RORIG	SEG	CA	1
Format	I5	I5	I5	
Variable	N	L	K	2
Format	F15.8	F15.8	F15.8	
Variable	CX	CY	FINT	3
Format	F15.8			
Variable	A			Next N cards
Format	F15.8			
Variable	XA			Next L cards
Format	F15.8			
Variable	XE			Next K cards

Output Data

The first output will be the input data punched in the same format as it was read in, except cards 3 and 2 are punched on one card. Following that, a header card will be punched and then the x coordinate, y coordinate, and derivatives of the curve as required. The curve may be plotted simultaneously with this output, or the output may be omitted and only the plot obtained.

Sense Switch Settings

Switch 1	OFF	-	Both the first and second derivatives of the curve will be punched
Switch 1	ON	-	Only the first derivative will be punched
Switch 2	OFF	-	The curve will not be plotted
Switch 2	ON	-	The curve will be plotted
Switch 3	OFF	-	All output will be punched
Switch 3	ON	-	No output will be punched

All the switch positions may be changed any time during the execution of the program to obtain partial data.

B. SAMPLE PROBLEM FOR GOBACK 3

Input Data

```
0.0              5.0              19.50
11    9    0
0.05             0.125            25.5
   0.0
   0.0
   0.0000000
  -0.2068768
  -0.8883194
   1.7682645      Coefficients
  -1.9088810
   2.0039195
  -1.6010168
   2.7202405
  -0.25504729
25.5
38.25
51.0
63.75             x coordinates of
76.5              original data offsets
89.25
102.0
114.75
127.5
```

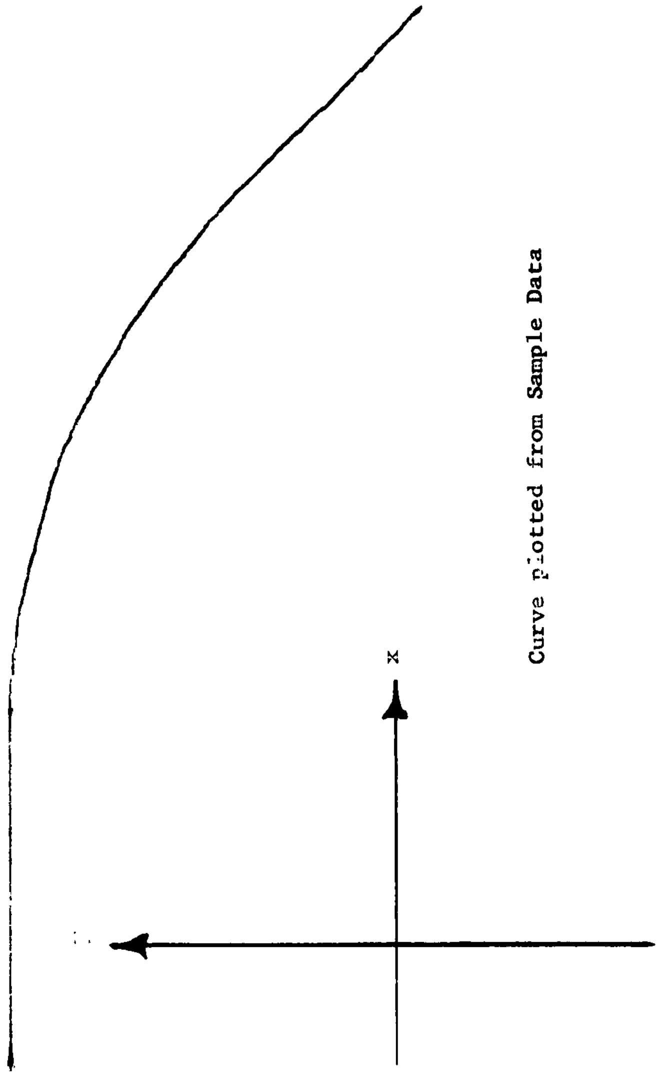
Output

```
   .00000000      5.00000000     19.50000000
   .05000000       .12500000     25.50000000    11     9
  1        .00000000
  2        .00000000
  3        .00000000
  4      -.20687680
  5      -.88831940
  6      1.76826450
  7     -1.90888100
  8      2.00391950
  9     -1.60101680
 10      2.72024050
 11      -.25504720
  1     25.50000000
  2     38.25000000
  3     51.00000000
  4     63.75000000
  5     76.50000000
```

(Continued on next page)

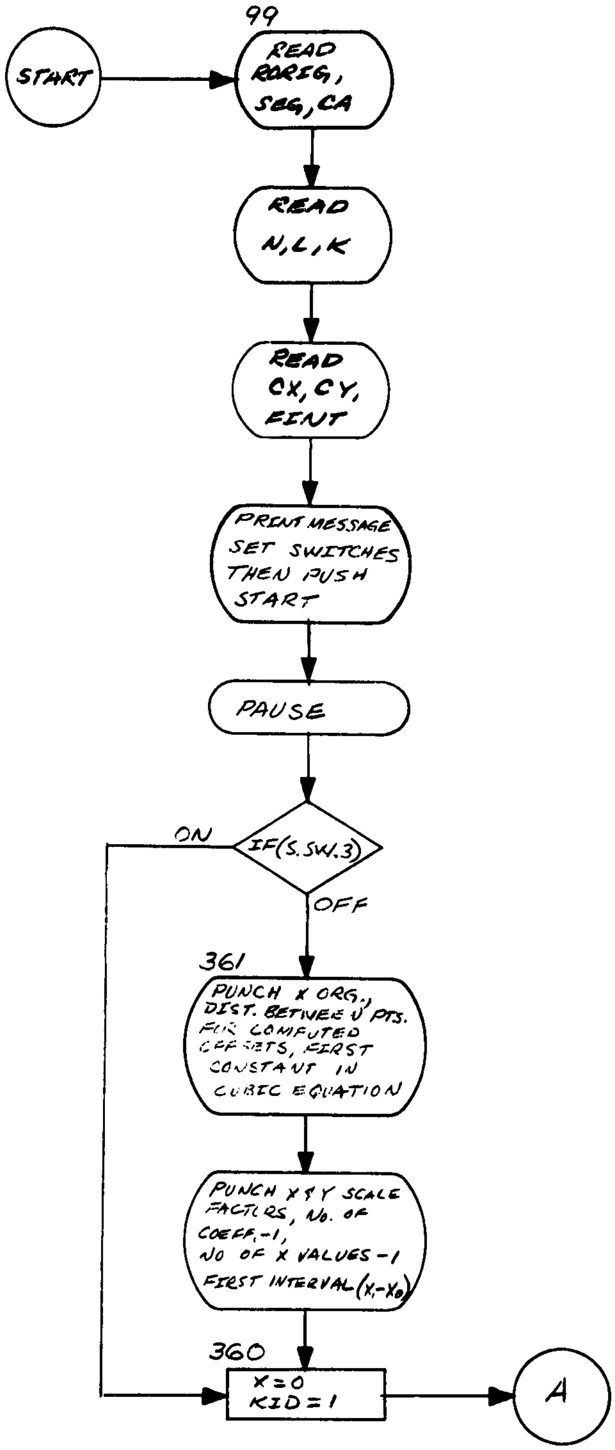
6	89.25000000
7	102.00000000
8	114.75000000
9	127.50000000

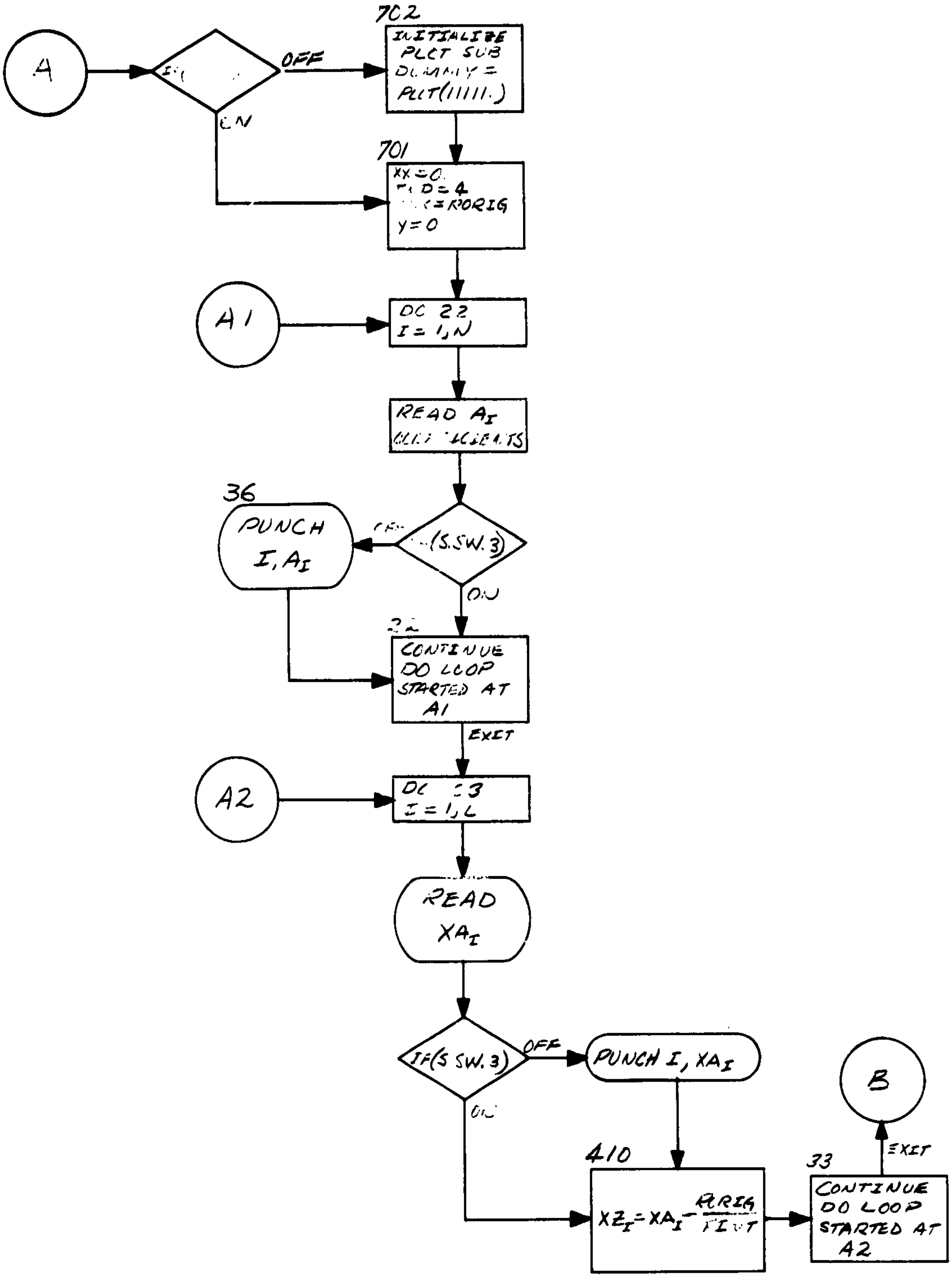
X	Y	FIRST DERIVAT.
.00000000	19.50000000	.00000000
5.00000000	19.50000000	.00000000
9.99999990	19.50000000	.00000000
15.00000000	19.50000000	.00000000
20.00000000	19.50000000	.00000000
25.00000000	19.50000000	.00000000
25.50000000	19.50000000	.00000000
29.99999800	19.49886400	-.00075794
35.00000000	19.48930300	-.00337800
38.25000000	19.47414100	-.00608461
39.99999900	19.46167700	-.00836172
44.99999800	19.39101300	-.02155531
50.00000000	19.22961200	-.04465637
51.00000000	19.18208500	-.05046548
54.99999900	18.93476200	-.07254610
59.99999800	18.51419200	-.09466698
63.75000000	18.13450500	-.10726189
65.00000000	17.99801600	-.11123872
69.99999900	17.38924400	-.13413327
74.99999800	16.63805100	-.16820734
76.50000000	16.37656200	-.18060960
80.00000000	15.69371800	-.20901960
84.99999900	14.55902700	-.24369906
89.25000000	13.47049500	-.26771338
89.99999800	13.26826900	-.27159293
94.99999800	11.83795200	-.30178948
99.99999900	10.23781400	-.33952080
102.00000000	9.54177140	-.35672312
105.00000000	8.43461480	-.38035745
110.00000000	6.46138250	-.40608937
114.75000000	4.50586050	-.41472047
115.00000000	4.40217670	-.41475082
120.00000000	2.34013220	-.40760490
125.00000000	.35073487	-.38569304
127.50000000	-.59364910	-.36919978



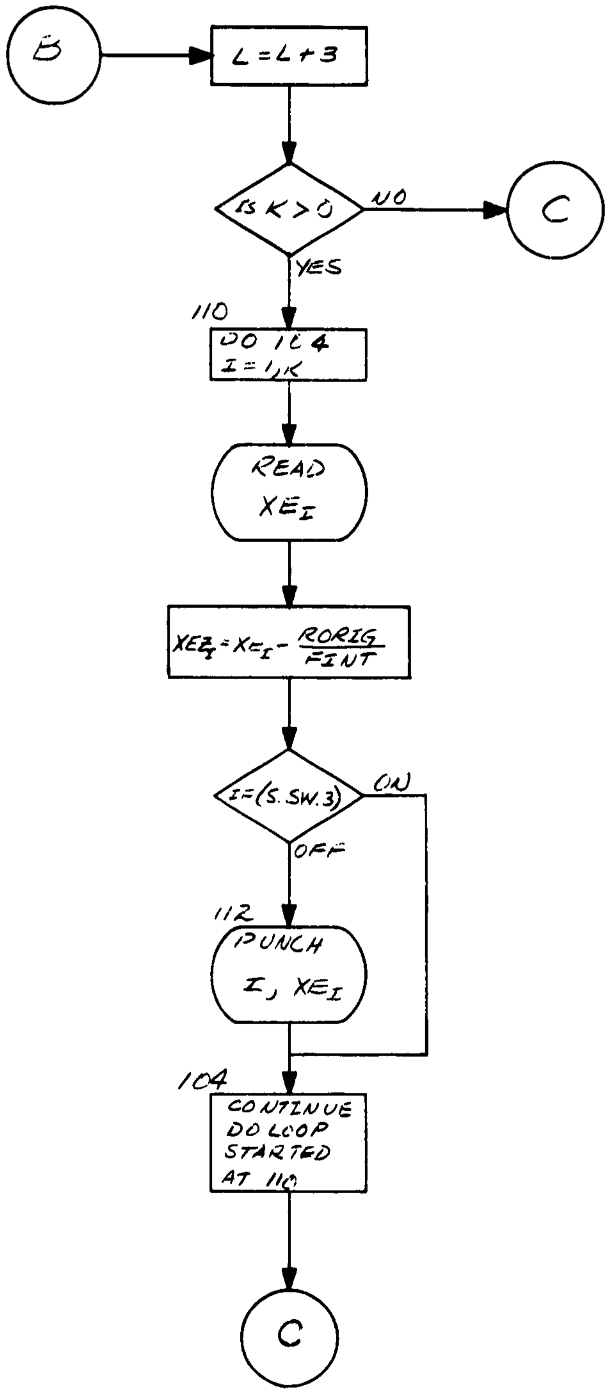
Curve plotted from Sample Data

C. FLOW DIAGRAM

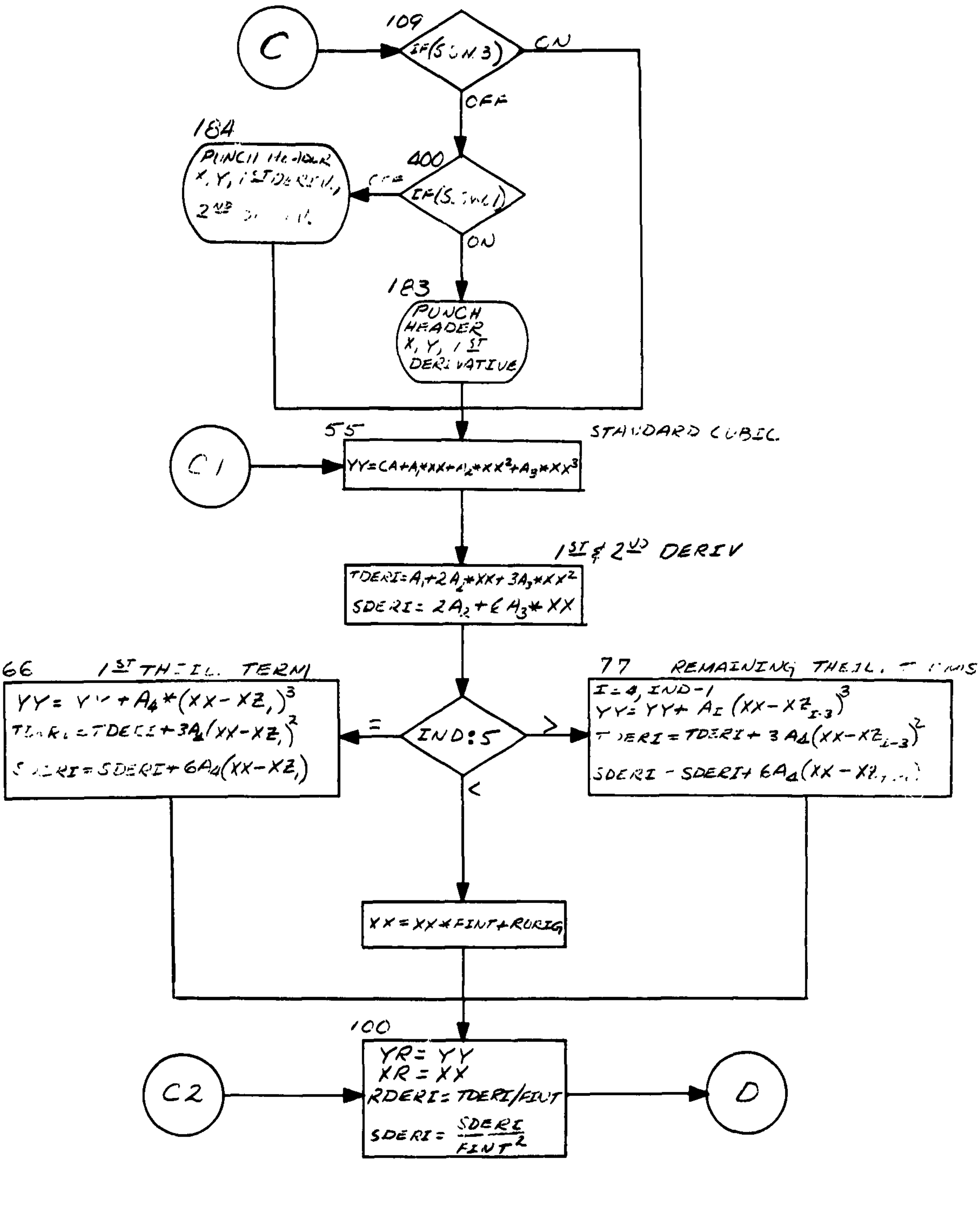




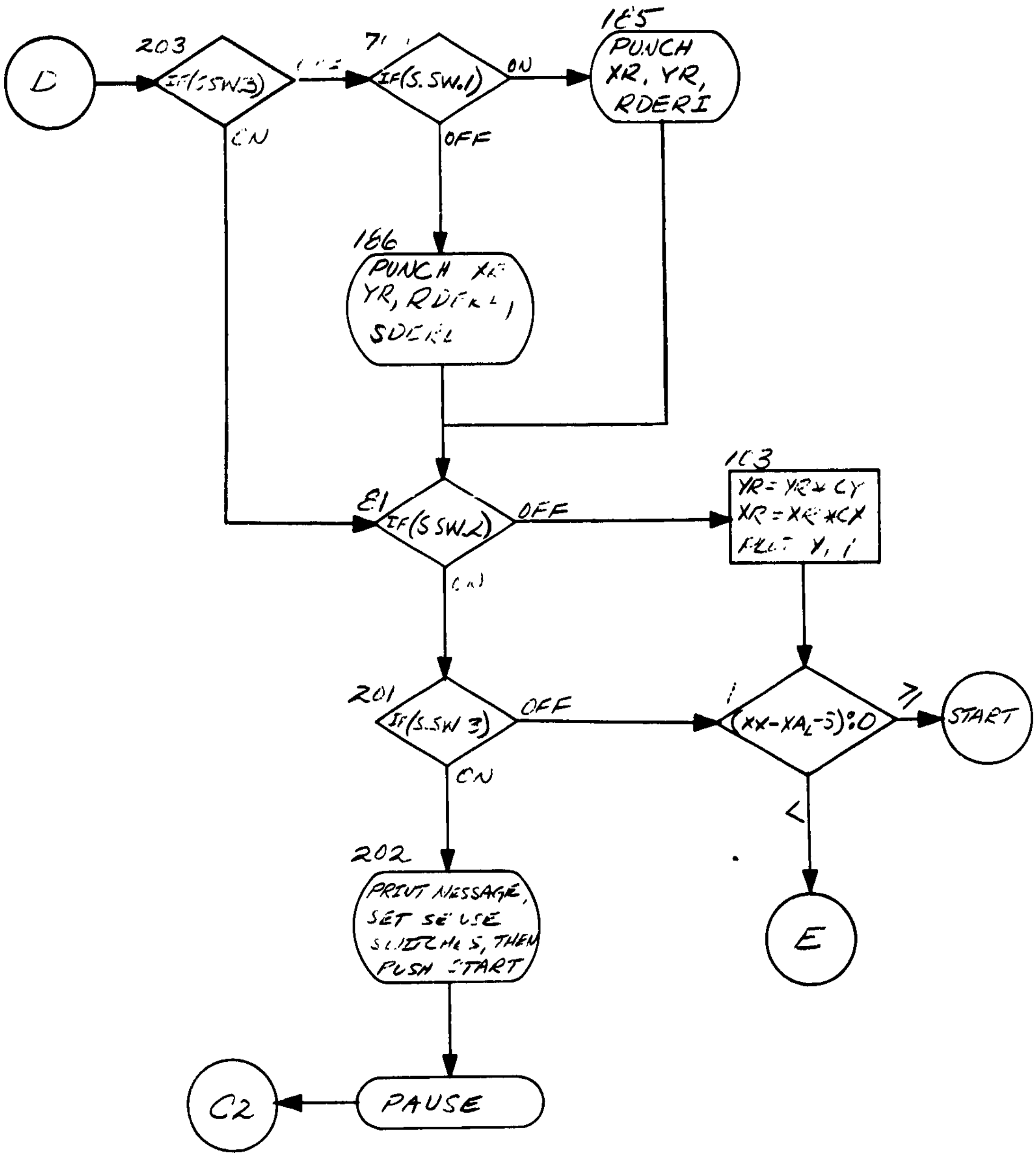
A
OFF
ON
702
INITIALIZE PLOT SUB DUMMY = PLOT(11111.)
701
XX = 0.
Y = 0
A1
DO 22 I = 1, N
READ A_I
36
PUNCH I, A_I
(S.SW.3)
OFF
ON
CONTINUE DO LOOP STARTED AT A1
EXIT
A2
DO 33 I = 1, L
READ XA_I
IF(S SW.3)
OFF
ON
PUNCH I, XA_I
410
B
EXIT
33
CONTINUE DO LOOP STARTED AT A2

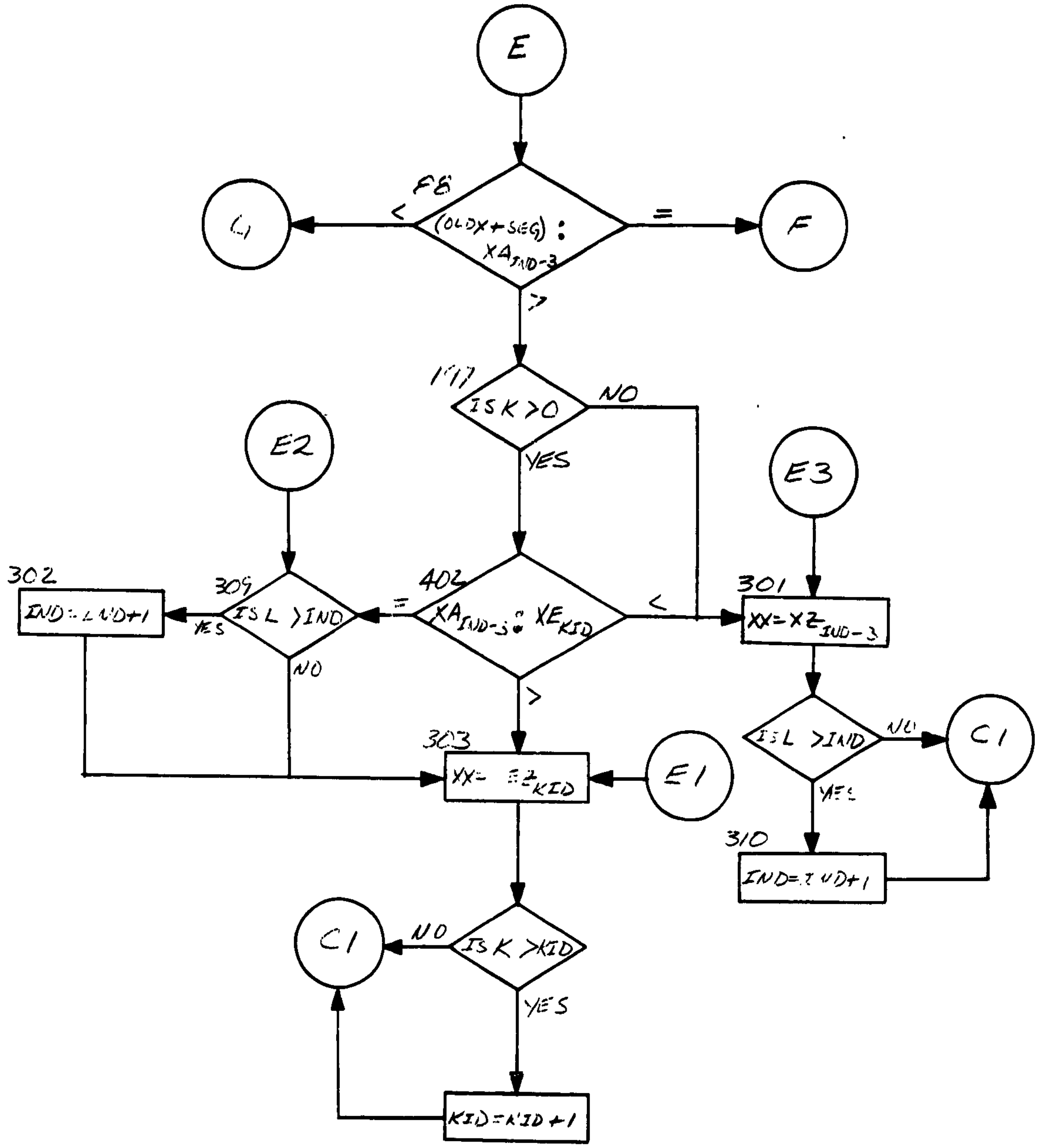


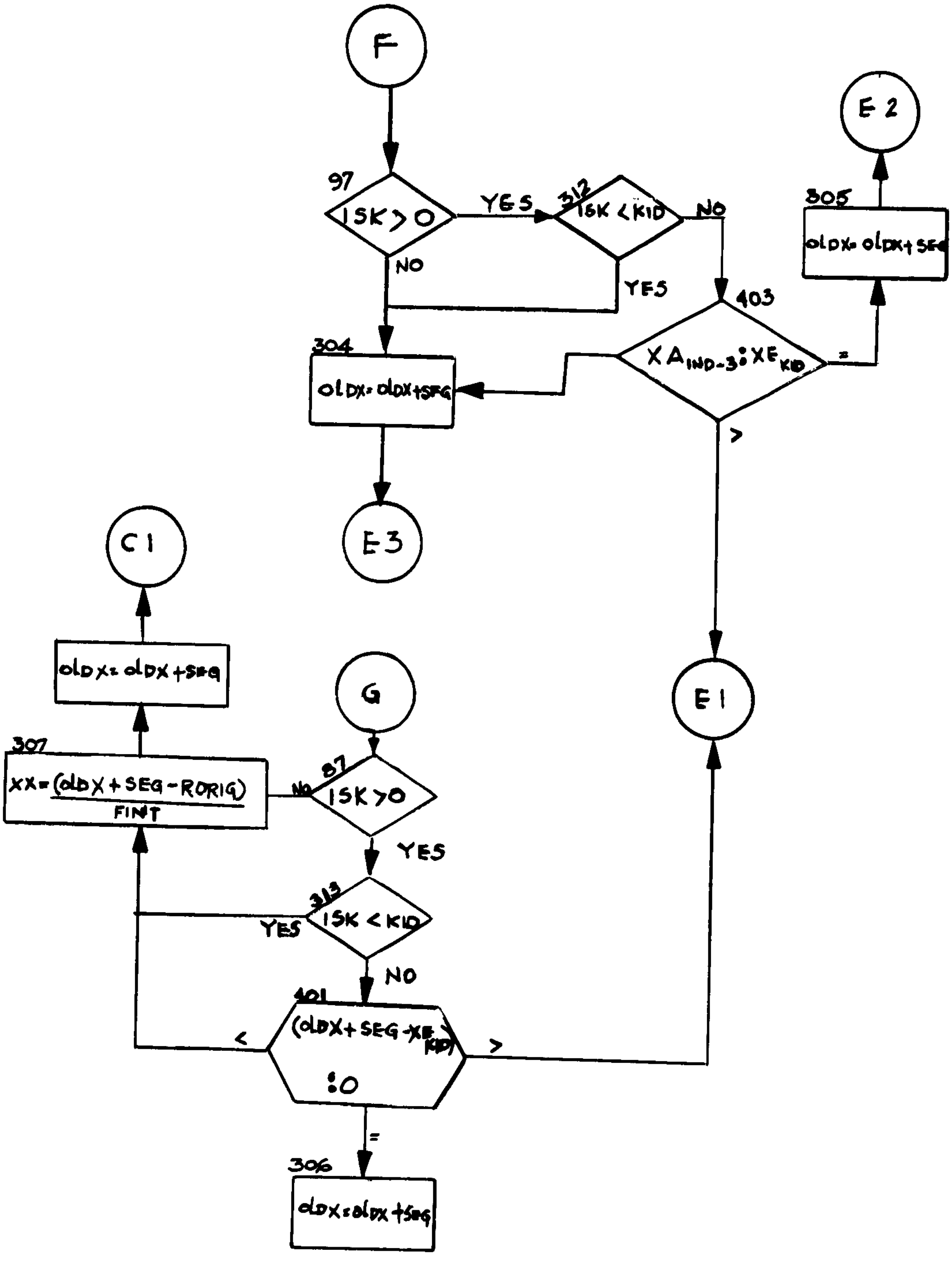
B
L=L+3
IS K>0
NO
C
YES
110
DO 104
I=1,K
READ
XE_I
XE2_I=XE_I - RORIG/FINT
I=(S.SW.3)
ON
OFF
112
PUNCH
I, XE_I
104
CONTINUE
DO LOOP
STARTED
AT 110
C



C
109
IF(S.W.3)
ON
OFF
184
PUNCH HEADER X, Y, 1ST DERIV., 2ND DERIV.
400
IF(S.W.1)
OFF
ON
183
PUNCH HEADER X, Y, 1ST DERIVATIVE
55
STANDARD CUBIC
C1
YY=CA+A1*XX+A2*XX2+A3*XX3
1ST & 2ND DERIV
TDERI=A1+2A2*XX+3A3*XX2
SDERI= 2A2+6A3*XX
66
1ST THEIL TERM
YY= YY+A4*(XX-XZ1)3
TDERI=TDERI+3A4(XX-XZ1)2
SDERI=SDERI+6A4(XX-XZ1)
IND:5
=
>
<
77
REMAINING THEIL TERMS
I=4, IND-1
YY=YY+AI(XX-XZI-3)3
TDERI=TDERI+3A4(XX-XZI-3)2
SDERI=SDERI+6A4(XX-XZI-3)
XX=XX*FINT+RORIG
100
YR=YY
XR=XX
RDERI=TDERI/FINT
SDERI=SDERI/FINT2
C2
D


D
203
IF(S.SW.3)
ON
IF(S.SW.1)
ON
OFF
185
PUNCH XR, YR, RDERI
186
PUNCH XR YR, RDERI, SDERI
81
IF(S.SW.2)
OFF
103
YR = YR * CY
XR = XR * CX
PLOT Y, 1
201
IF(S.SW 3)
OFF
ON
1
(XX-XAL-5):0
71
START
E
202
PRINT MESSAGE, SET SENSE SWITCHES, THEN PUSH START
PAUSE
C2


E
F8
(OLDX + SEG) : XA IND-3
<
=
>
F
177
IS K > 0
NO
YES
E2
E3
402
XA IND-3 : XE KID
309
IS L > IND
YES
NO
302
IND = IND+1
301
XX = XZ IND-3
IS L > IND
NO
YES
C1
310
IND = IND+1
303
XX = EZ KID
E1
IS K > KID
NO
YES
C1
KID = KID + 1


F
97
ISK > O
YES
312
ISK < KID
NO
NO
YES
403
$XA_{IND-3} : XE_{KID}$
=
305
oLDX = oLDX + SEG
E 2
304
oLDX = oLDX + SEG
>
E3
C1
oLDX = oLDX + SEG
G
E1
307
XX = (oLDX + SEG - RORIG) / FINT
NO
87
ISK > O
YES
313
ISK < KID
YES
NO
401
$(oLDX + SEG - XE_{KID}) : 0$
<
>
=
306
oLDX = oLDX + SEG

D. LISTING

```
C       * *  2D GO BACK  -     .      * *
      DIMENSION XA(100),A(100),B(100),XZ(100),XE(100),XEZ(100)
99    READ 2,RORIG,SEG,CA
      READ 7,N,L,K
      READ 2,CX,CY,FINT
      PRINT 42
      PAUSE
      IF (SENSE SWITCH 3) 360,361
361   PUNCH 2, RORIG,SEG,CA
      PUNCH24,CX,CY,FINT,N,L,K
360   X=0.
      KID=1
      IF(SENSE SWITCH 2)701,702
702   DUMMY=PLOT(11111.)
701   XX=0.
      IND=4
      OLDX=RORIG
      Y=0.
       DO 22 I=1,N
      READ 2,A(I)
      IF (SENSE SWITCH 3)22,36
36     PUNCH 26,I,A(I)
22     CONTINUE
      DO 33 I=1,L
      READ 2,XA(I)
      IF (SENSE SWITCH 3) 410,39
39     PUNCH 26,I,XA(I)
410   XZ(I)=(XA(I)-RORIG)/FINT
33     CONTINUE
      L=L+3
      IF(K)109,109,110
110   DO 104 I=1,K
      READ 2,XE(I)
      XEZ(I)=(XE(I)-RORIG)/FINT
      IF(SENSE SWITCH 3)104,112
112   PUNCH 26,I,XE(I)
104   CONTINUE
109   IF(SENSE SWITCH 3) 55,400
400   IF(SENSE SWITCH 1)183,184
183   PUNCH 44
      GO TO 55
184   PUNCH 43
55    YY=CA+A(1)*XX+A(2)*(XX**2)+A(3)*(XX**3)
      TDERI=A(1)+A(2)*2.*XX+A(3)*3.*XX*XX
      SDERI=A(2)*2.+A(3)*6.*XX
      IF(IND-5)100, 66,77
66    YY=YY+((XX-XZ(1))**3)*A(4)
      TDERI=TDERI+3.*A(4)*((XX-XZ(1))**2)
      SDERI=SDERI+6.*A(4)*(XX-XZ(1))
```

```
      GO TO 100
77    IN=IND-1
503   DO 78 I=4,IN
      TDERI=TDERI+(3.*A(I)*((XX-XZ(I-3))**2))
      SDERI=SDERI+(6.*A(I)*(XX-XZ(I-3)))
78    YY=YY+((XX-XZ(I-3))**3)*A(I)
100    XX=XX*FINT+RORIG
      YR=YY
      XR=XX
      RDERI=TDERI/FINT
      SDERI=SDERI/(FINT*FINT)
203   IF(SENSE SWITCH 3)81,700
700   IF(SENSE SWITCH 1)185,186
185   PUNCH 40, XR,YR,RDERI
      GO TO 81
186   PUNCH 40, XR,YR,RDERI,SDERI
81    IF(SENSE SWITCH 2)201,103
201   IF(SENSE SWITCH 3)202,1
202   PRINT 42
      PAUSE
      GO TO 203
103   YR=YR*CY
      XR=XR*CX
      DUMMY=PLOT(YR)
1     IF(XX-XA(L-3))88,99,99
88    IF((OLDX+SEG)-XA(IND-3))87,97,197
197   IF(K)301,301,311
311   IF(K-KID)301,402,402
402   IF(XA(IND-3)-XE(KID))301,309,303
303   XX=XEZ(KID)
      IF(K-KID)55,308,308
308   KID=KID+1
      GO TO 55
309   IF(L-IND)303,303,302
302   IND=IND+1
      GO TO 303
301   XX=XZ(IND-3)
      IF(L-IND)55,55,310
310   IND=IND+1
      GO TO 55
97    IF(K)304,304,312
312   IF(K-KID)304,403,403
403   IF(XA(IND-3)-XE(KID))304,305,303
305   OLDX=OLDX+SEG
      GO TO 309
304   OLDX=OLDX+SEG
      GO TO 301
87    IF(K)307,307,313
313   IF(K-KID)307,401,401
```

```
401 IF(OLDX+SEG-XE(KID))307,306,303
306 OLDX=OLDX+SEG
    GO TO 303
307 XX=(OLDX+SEG-RORIG)/FINT
    OLDX=OLDX+SEG
    GO TO 55
2   FORMAT(4F15.8)
7   FORMAT(I5,I5,I5)
24  FORMAT(3F15.8,I5,I5,I5)
26  FORMAT (I6,F15.8)
40  FORMAT(8X,F15.8,3X,3F15.8)
42  FORMAT(29HSET SWITCHES, THEN PUSH START)
43  FORMAT(16X,1HX,17X,1HY,7X,14HFIRST DERIVAT.,1X,15HSECOND DERIVAT
   .)
44  FORMAT(16X,1HX,17X,1HY,7X,14HFIRST DERIVAT.)
    END
```

Appendix E

PROGRAM FOR CONVERSION OF STANDARD CUBIC COEFFICIENTS FOR NUMERICAL CONTROL

CONTENTS

Appendix E

PROGRAM FOR CONVERSION OF STANDARD CUBIC COEFFICIENTS FOR NUMERICAL CONTROL

OPERATING INSTRUCTIONS

This program accepts coefficients of cubic equations of the standard form:

$$Y = A + BX + CX^2 + DX^3$$
$$X_1 \leq X \leq X_2$$

with the following conditions:

(1) Y Units are feet

(2) X units are feet

(3) X_1 and X_2 units are feet

(4) X, X_1 , X_2 may be scaled

(5) The coefficients are in the normal fixed point format of FORTRAN, and are on cards as punched by GO BACK (See Fig. E-1)

These coefficients are converted to meet the following conditions

(1) Y units in inches

(2) X units in inches

(3) X_1 and X_2 in inches

(4) X , X_1 and X_2 rescaled - usually to full size

(5) The coefficients are presented in normalized, excess 50 floating point format similar to that used in SPS-I for the 1620 computer.

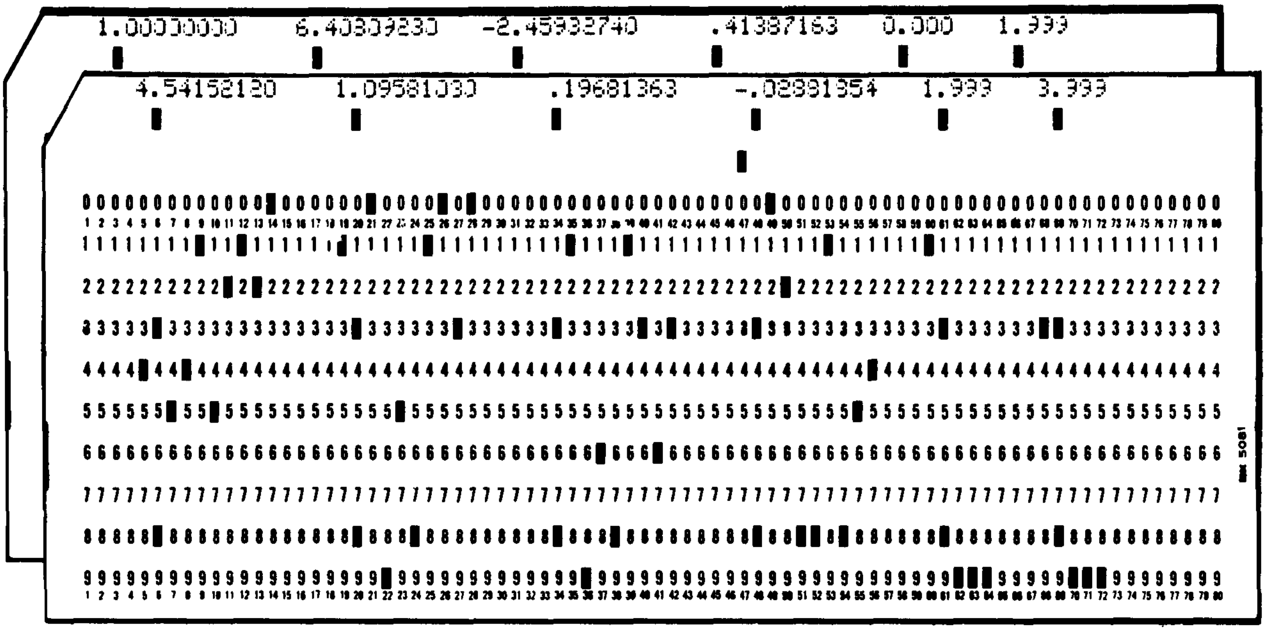
(6) The origin of the equation and its limits may have been translated along the X axis.

(7) The coefficients and limits are punched on a card along with the appropriate AUTOMAP statement as shown in Fig. E-1, and in an order such that the equation now reads:

$$Y = DX^3 + DX^2 + BX + A$$

As may be noted from the flow chart, this program contains a fairly concise

TYPICAL INPUT CARDS



TYPICAL OUTPUT CARDS

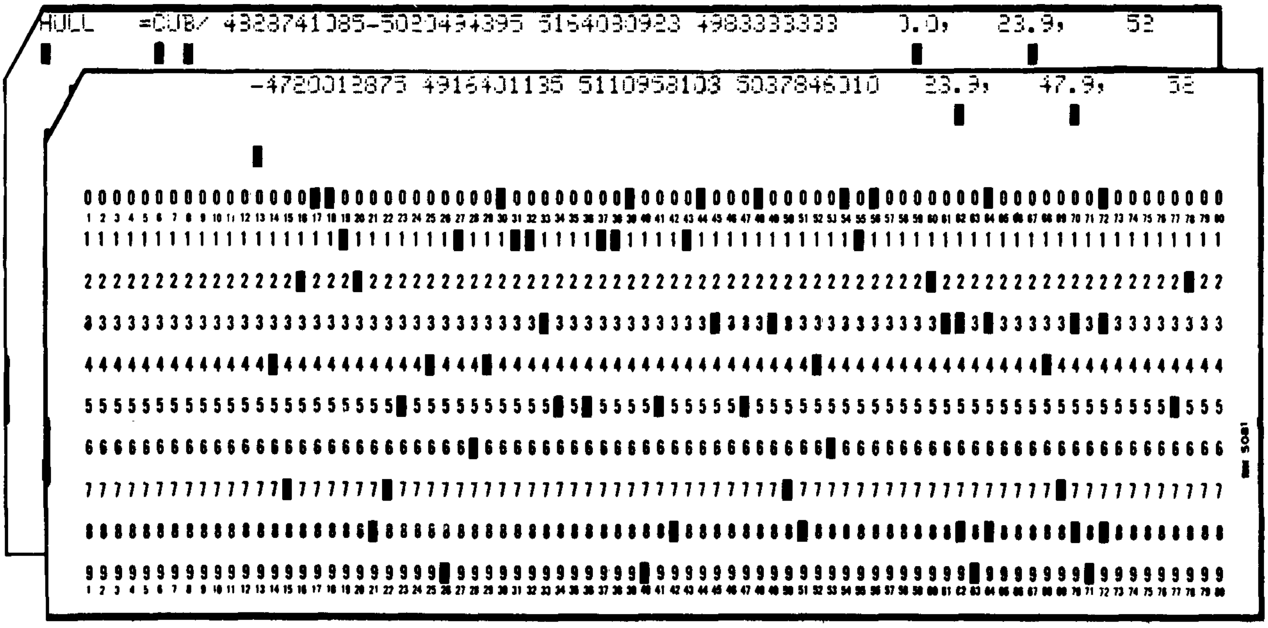


Fig. E-1 Typical Data Cards

routine for converting from fixed point to excess 50 normalized floating point in FORTRAN, as well as overcoming FORTRAN format difficulties in punching the resulting numbers.

A number of sets of coefficients, which together describe a given curve, may be processed at the same time. The AUTOMAP program requires that the first card of a particular set be punched with a different format than that of the others. The program does this automatically and also punches a curve identification number in each card of each set.

The program is written in FORTRAN II for the IBM-1620 computer. The variable word length feature of this version of FORTRAN has been used.

Integer numbers have been increased in length to ten digits. The length of floating point numbers remains at eight digits.

A. Input Data

	Symbol	Format	Card Columns	Definition
1st Card	N	I10	1-10	No. of segments
	T	F10.1	11-20	Translation Factor
	SF	F10.5	21-30	Scale Factor*
2nd and Remaining Cards				
	A,B,C,D	4F14.8	A 1-14 B 15-28 C 29-42 D 43-56	Cubic Coefficients
	XB	F8.1	57-64	Beginning Point
	XE	F8.1	65-72	Ending Point

*The X values of the limits and assumed in the equation are multiplied by the scale factor. Thus, the scale factor for doubling the curve length would be 2 .

b. **Output Data**

	Symbol	Format	Card Columns	Definition
Each Card				
	D,B,C,A	4I11	D 13-23 C 24-34 B 35-45 A 46-56	Converted Coefficients
	XB	F7.1	57-63	Beginning Point
	XE	F7.1	65-71	Ending Point
	ISTA	I5	73-77	Curve Identification

SAMPLE PROBLEM - CONVERSION OF STANDARD CUBIC COEFFICIENTS
FOR NUMERICAL CONTROL

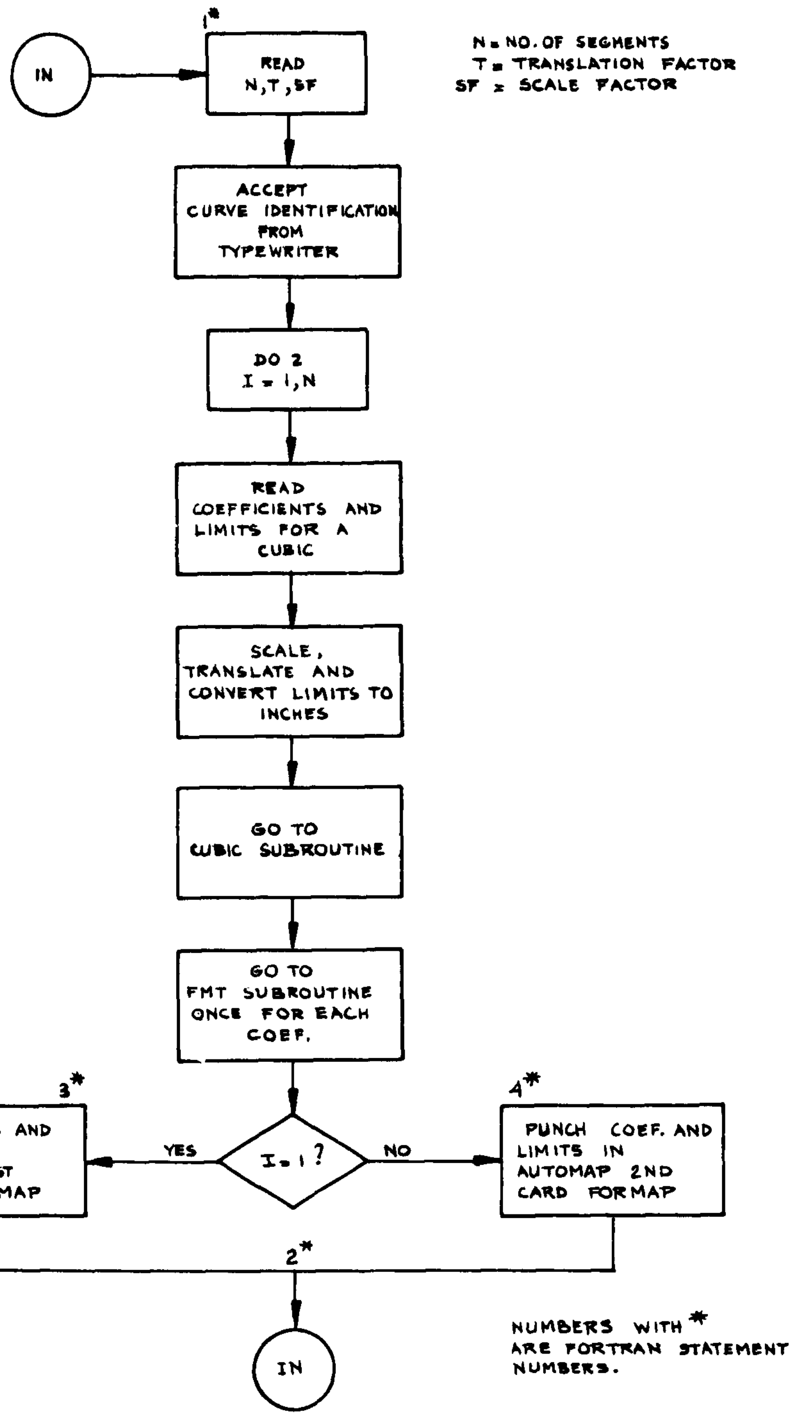
Input Data

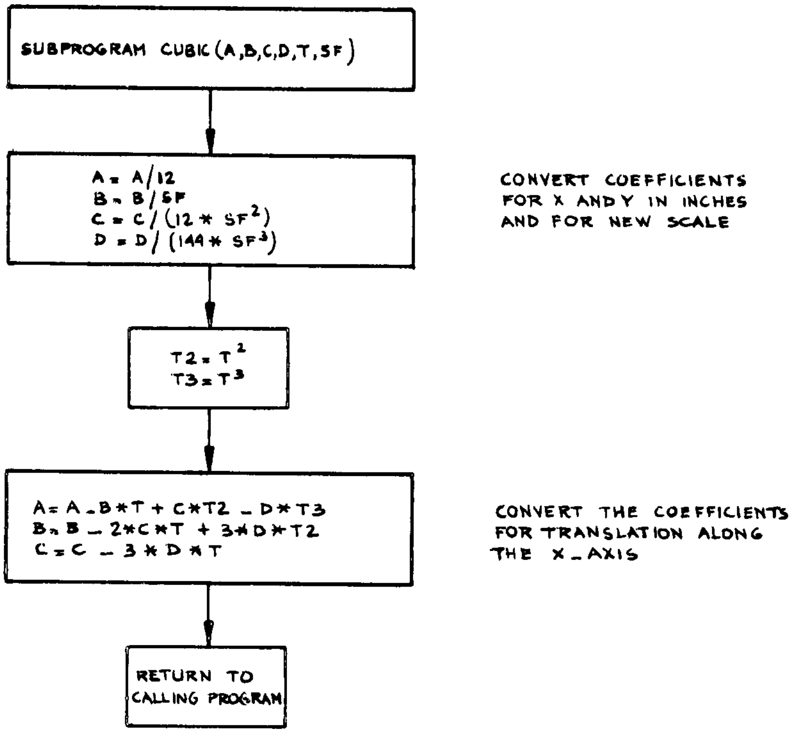
```
         N          T        SF

         5         0.0    1.00000
         A                B                  C                      D            START   FINIS

       1.00000000     6.40809230     -2.45932740        .41387163     0.000     1.99
9
       4.54152120     1.09581030       .19681363      -.02881854     1.999     3.99
9
       2.37012650     2.94935630      -.26657288       .00979699     3.999     7.99
9
       6.39770760     1.32651330      -.06371750       .00134469     7.999    12.00
0
       6.69046240     1.25332460      -.05761844       .00117527    12.000   15.999
```

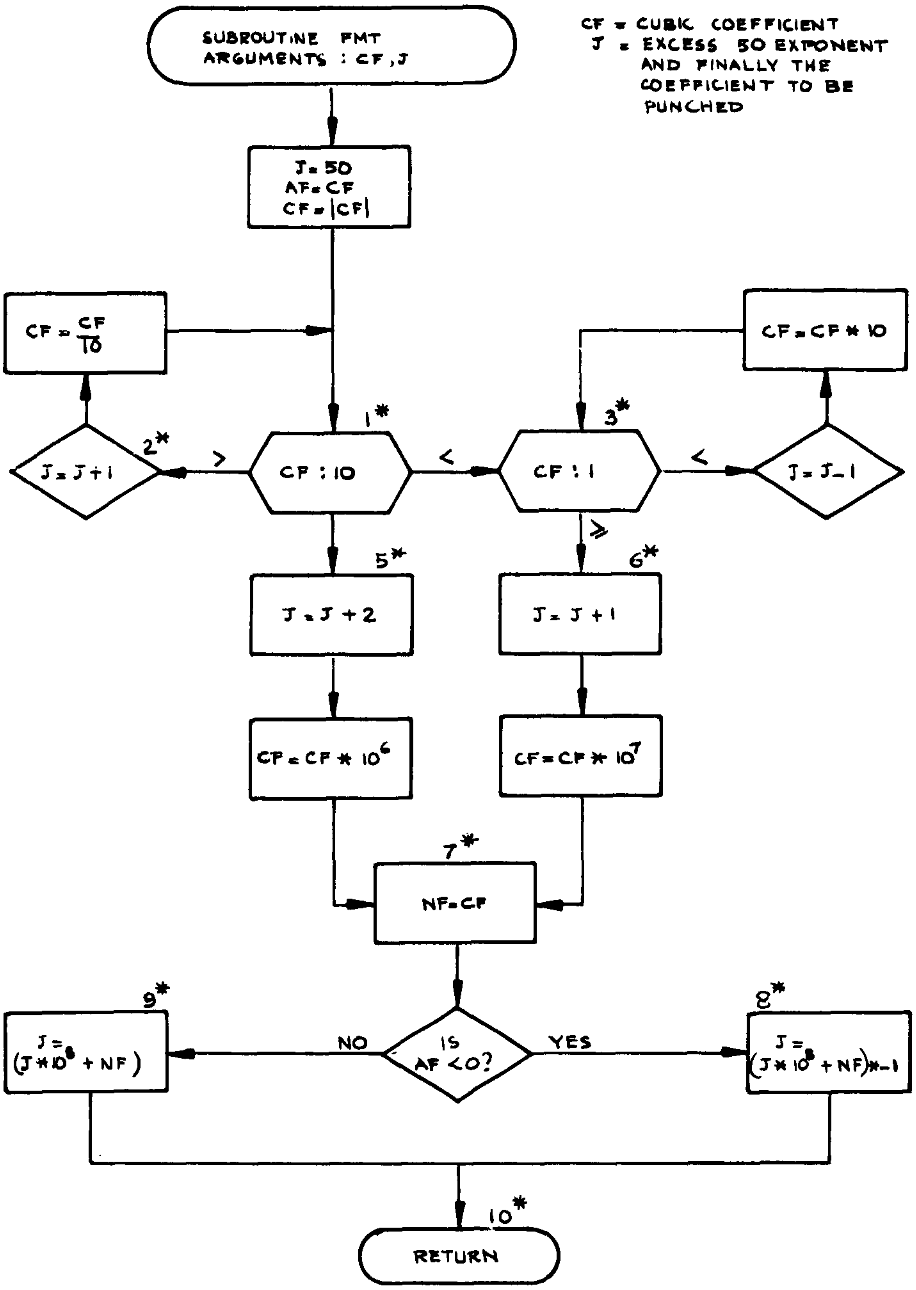
Output

```
                      D            C           B           A          XB        XE
     FR
 UL_    =CUB/ 4828741085-5020494395 5164080923 4983333333     0.0,    23.9
,     52
             -4720012875 4916401135 5110958103 5037846010    23.9,    47.
9,     52
              4668034652-4922214406 5129493563 5017251054    47.9,    95.
9,     52
              4593381250-4853097916 5113265133 5053314230    95.9,   144.0
,     52
              4581615972-4848015366 5112533246 5055753853   144.0,   191.
9,     52
```

PROGRAM FLOW CHART - CONVERSION OF STANDARD CUBIC COEFFICIENTS FOR NUMERICAL CONTROL




SUBPROGRAM CUBIC (A,B,C,D,T,SF)
A = A/12
B = B/SF
C = C/(12 * SF^2)
D = D/(144 * SF^3)
CONVERT COEFFICIENTS FOR X AND Y IN INCHES AND FOR NEW SCALE
T2 = T^2
T3 = T^3
A = A - B*T + C*T2 - D*T3
B = B - 2*C*T + 3*D*T2
C = C - 3*D*T
CONVERT THE COEFFICIENTS FOR TRANSLATION ALONG THE X-AXIS
RETURN TO CALLING PROGRAM


SUBROUTINE FMT
ARGUMENTS : CF, J
CF = CUBIC COEFFICIENT
J = EXCESS 50 EXPONENT AND FINALLY THE COEFFICIENT TO BE PUNCHED
J = 50
AF = CF
CF = |CF|
CF = CF/10
CF = CF * 10
1*
2*
3*
J = J + 1
>
CF : 10
<
CF : 1
<
J = J - 1
≥
5*
6*
J = J + 2
J = J + 1
CF = CF * 10^6
CF = CF * 10^7
7*
NF = CF
9*
8*
J = (J * 10^8 + NF)
NO
IS AF < 0?
YES
J = (J * 10^8 + NF) * -1
10*
RETURN

PROGRAM LISTING - CONVERSION OF STANDARD CUBIC COEFFICIENTS FOR NUMERICAL CONTROL

```
*0810
    1 READ 150,N,T,SF
      T=T*12.
      ACCEPT 149,ISTA
      DO 2 I=1,N
      READ 151,A,B,C,D,XB,XE
      XB=(XB*12.*SF)+T
      XE=(XE*12.*SF)+T
      CALL CUBIC(A,B,C,D,T,SF)
      J1=0
      J2=0
      J3=0
      J4=0
      CALL FMT(A,J4)
      CALL FMT(B,J3)
      CALL FMT(C,J2)
      CALL FMT(D,J1)
      IF(I-1)3,3,4
    3 PUNCH 152,J1,J2,J3,J4,XB,XE,ISTA
      GO TO 2
    4 PUNCH 153,J1,J2,J3,J4,XB,XE,ISTA
    2 CONTINUE
     PAUSE
      GO TO 1
  149 FORMAT(I5)
  153 FORMAT(12X,4I11,F7.1,1H,,F7.1,1H,,1X,I5)
  152 FORMAT(12HHULL    =CUB/,4I11,F7.1,1H,,F7.1,1H,,1X,I5)
  151 FORMAT(4F14.8,2F8.1)
  150 FORMAT(I10,F10.1,F10.5)
      END
*0810
      SUBROUTINE CUBIC(A,B,C,D,T,SF)
      A=A/12.
      B=B/SF
      C=C/(12.*SF*SF)
      D=D/(144.*SF*SF*SF)
      T2=T*T
      T3=T2*T
      A=A-B*T+C*T2-D*T3
      B=B-2.*C*T+3.*D*T2
      C=C-3.*D*T
      RETURN
      END
*0810
      SUBROUTINE FMT(CF,J)
      AF=CF
      CF=ABSF(CF)
      J=50
    1 IF(CF-10.)3,5,2
    2 J=J+1
      CF=CF/10.
```

```
      GO TO 1
    3 IF(CF-1.)4,6,6
    4 J=J-1
      CF=CF*10.
      GO TO 3
    5 J=J+2
      CF=CF*1000000.
      GO TO 7
    6 J=J+1
      CF=CF*10000000.
    7 NF=CF
      IF(AF)8,9,9
    8 J=(J*100000000+NF)*(-1)
      GO TO 10
    9 J=J*100000000+NF
   10 RETURN
      END
```

Appendix F

PLOTTING ROUTINES

CONTENTS

Appendix F

PLOTTING ROUTINES

INTRODUCTION

When working with mathematical equations for curves, particularly if there are certain requirements on the characteristics of the curves, it is desirable to have some type of automatic plotting device. This will provide an accurate picture of the contour of the curve and permit a subjective analysis of the curve's characteristics.

The plotting device used in developing this system consists of a small digital incremental plotter (CalComp Model 560-R) which is connected directly to the IBM-1620 computer. By means of a switch, output signals normally routed to the paper tape punch of the computer can be channeled directly to the plotter instead. By feeding the plotter a series of digits (0, ... , 9) which it recognizes as instructions (See Section I of this Appendix), line increments can be drawn.

The purpose of the plotting program is to feed the plotter the series of digits which will cause the plotter to draw a line between any two given points. If enough points to describe the periphery of an object are made available to the plotting program in order, it will cause the plotter to draw a picture of that object.

Plotting routines which accept data points from two different sources are included with this report: first, the plotting program, which reads data directly from cards processed through the card reader (see Section II of this Appendix for operating instructions); and second, the plotting subroutine which is used with a master FORTRAN program.

The master FORTRAN program collects or calculates the desired data points,

and places them in certain computer memory locations It then calls on the plotting subroutine which plots the calculated points.

There are two versions of this subroutine: one is meant to be placed in a **FORTRAN** I subroutine deck (see the program listing in Section V of this Appendix); the other is meant for the **FORTRAN** II subroutine deck (see program listing in Section VI). The use and operating instructions of each of these programs are the same (Section III), only the program instructions themselves change

All of the plotting programs are written in SPS-1 for the IBM-1620 computer The subroutine programs are intended for a machine with 60-K digits of memory. The plotting program can be used with any size memory.

PLOT SUBROUTINE

METHOD

The plotter traces straight line increments along one of the eight directions (four axes) shown in Fig. 1. The increments are .01" in the X and Y directions, and .01414" for the inclined directions.

A punch tape instruction, 1, 2, 3, ..., 8, will move the plotter in one of eight specific directions. Instruction 0 will raise the pen, and 9 will lower the pen.

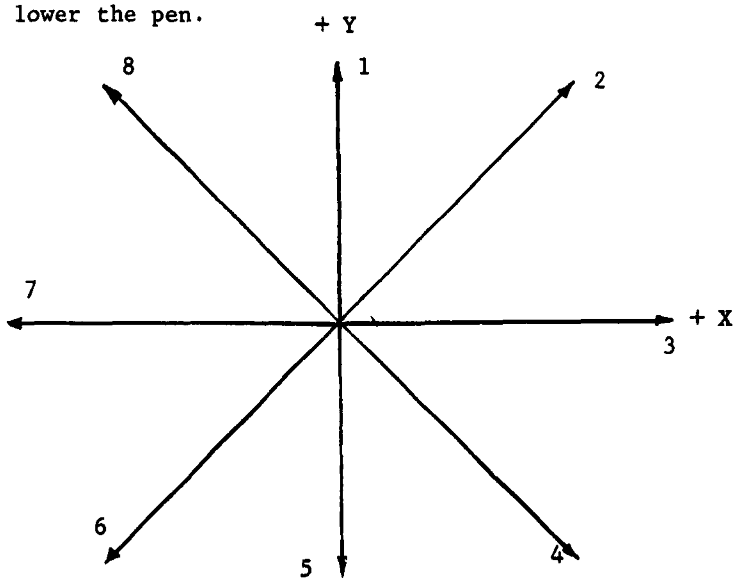


Fig. 1 Direction of Movement of Plotter

Given a particular quadrant (Fig. 2), and a specific point, the line connecting this point to the origin must fall in one of the five cases listed below:

Case 1	Point P :	$\Delta Y = 0$
Case 2	Point Q :	$\Delta X > \Delta Y$
Case 3	Point R :	$\Delta X = \Delta Y$
Case 4	Point S :	$\Delta Y > \Delta X$
Case 5	Point T :	$\Delta X = 0$

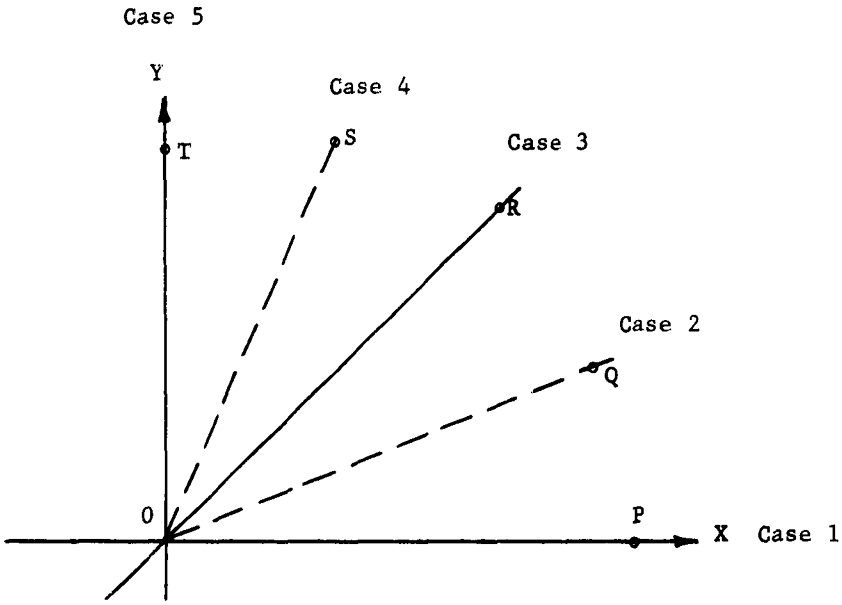


Fig. 2

After determining the case, the problem is reduced to positioning the point to one side of the bisector of the quadrant.

For Point P having a null or less than .005 increment in the Y direction, the procedure is as follows:

1. Round off the increment at the 1/100 position by adding or subtracting .005 to its value if positive or negative respectively.
2. Add this rounded value to the corresponding coordinate of Point 0 and store it as the origin to determine the increment for the next point to be joined.
3. Check for digit in the units position of the absolute value of the increment for fast one-inch moves.
4. Check for digit in the 1/10 position for fast 1/10th-inch moves.
5. Test for digit in the 1/100 position for single moves.

By subtracting one from the corresponding position after each move, the increment will be zero at the completion of the total move.

For Point R the procedure is the same as mentioned above for Point P with the difference that both increments X and Y ..., (Fig. 2) will be rounded off and added to the coordinates of Point 0 .

The method for plotting those Points Q having unequal increments in X and Y is as follows:

1. Get the ratio of the smaller to the larger increment in absolute value.
2. Round off the increments X and Y and add them to the coordinates of the Point 0 to use these new values as the origin to calculate the increments for the next point to be joined.
3. Approximate the line $\overline{0Q}$ (Fig. 3) with segments $\overline{0A}$, $\overline{AB}$, etc., in the following manner.
4. Set an XY counter equal to .005
5. Add $\overline{MN}$ (Ratio x .01") to the counter
6. Compare the counter with $\overline{AM}$ (= .01) (check for digit in the 1/100 position)
   a. If the counter is greater, it means that we are closer to the actual line going through the diagonal rather than the horizontal line

$$\overline{MN} + .005 > \overline{AM}$$

$$\therefore \overline{AM} - \overline{MN} < .005$$

   (Note: The XY counter has to be reduced by $\overline{MA}$ after the diagonal move and the cycle goes back to Step 5.)

b. If the counter is less than $\overline{MA}$ the closest path is the horizontal line

$$\overline{MN} + .005 < \overline{AM}$$

$$\therefore \overline{AM} - \overline{MN} > .005$$

(Note: The cycle goes back directly to Step 5 after the horizontal move.)

An analysis of the moves from 0 to B of Fig. 3 will help to clarify the method

1. XY counter = $\overline{MN} + .005 > \overline{AM}$.
2. Move $\overline{OA}$
3. XY Counter = $\overline{MN} + .005 - \overline{AM}$
4. XY Counter = $\overline{MN} + .005 - \overline{AM} + \overline{MN}$

   $= 2\overline{MN} + .005 - \overline{AM}$
5. XY Counter = $\overline{LK} + .005 - \overline{AM} < \overline{AM}$

   $\therefore \overline{LK} + .005 < 2\overline{AM}$

   $.005 < \overline{HK} - \overline{LK}$
6. Move $\overline{AB}$

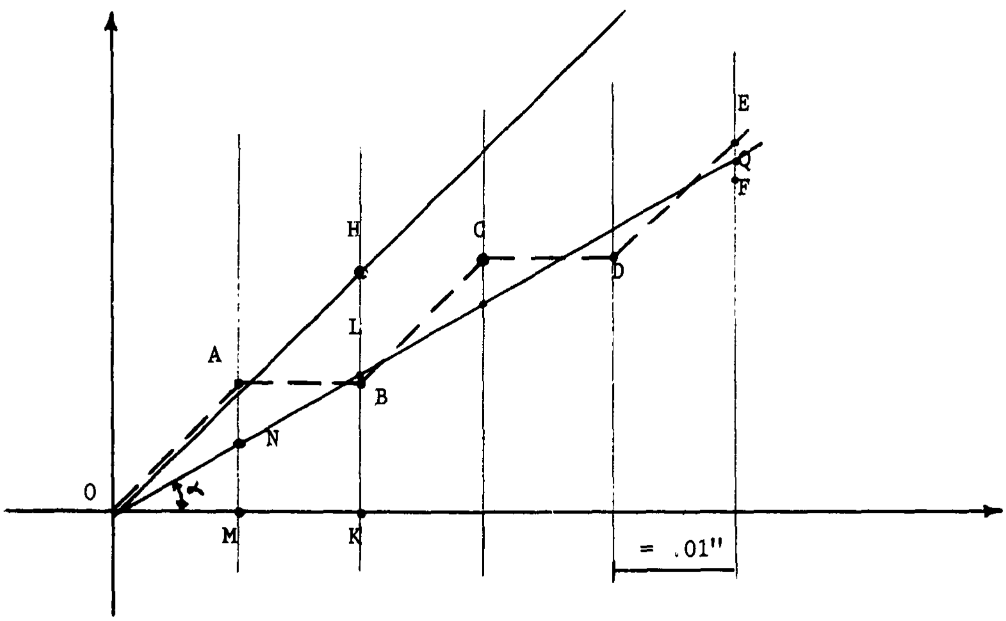


Fig 3

Section II

INSTRUCTIONS FOR USE OF THE PLOTTING PROGRAM

INPUT DATA

There are three types of input cards for the plotting program:

(1) Scaling data

(2) Pen raising and lowering instructions

(3) Coordinates of data points

(1) Scaling Card

If it is desired to plot the data at some scale other than 1" = 1 unit dimension, a scale factor must be entered with a value for scaling X and a value for scaling Y. The plotted values are determined by:

X = X (*) scale factor

Y = Y (*) scale factor

The format for this card is given below:

Card columns	Contents
1 - 9	Blank
10	Minus (-) for negative X scale factor, Blank for positive
11 - 19	X scale factor
15	Decimal point for X scale factor
20 - 27	Blank
28	Minus (-) for negative Y scale factor
29 - 37	Y scale factor
33	Decimal point for Y scale factor
38 - 80	Any alphanumeric information

If scaling is required, this card must be the first valid* card of the data deck.

*Only cards with a decimal point in Column 15 are recognized by this program.

(2) <u>Pen Raising or Lowering Instruction Cards</u>

Cards must be placed in the deck to inform the program when the plotter pen must be raised or lowered. These cards have the following format. Any card which does not have a decimal point in Column 15 is ignored.

<u>Pen Down Card</u>

Card Columns	1 - 10	11 ,	12 ,	13 ,	14 ,	15	16 - 38	39 - 80
Contents	Blank	5	0	0	0	.	Blank	Anything

<u>Pen Up Card</u>

Card Columns	1 - 10	11 ,	12 ,	13 ,	14 ,	15	16 - 38	39 - 80
Contents	Blank	6	0	0	0	.	Blank	Anything

(3) <u>Data Coordinate Cards</u>

Coordinates of points to be plotted are presented one set to a card in the following format. The origin of the picture will always be the first point in the data set.

Card Columns	Contents
1 - 9	Blank or any alphanumeric information (ignored by the plotting program)
10	Minus (-) if the X coordinate is negative, blank if plus
11 - 19	X coordinate of point to be plotted
15	Decimal point of X coordinate
20 - 27	Same as Cols. 1 - 9
28	Minus (-) if the Y coordinate is negative, blank if plus
29 - 37	Y coordinate of point
33	Decimal point of Y coordinate
38 - 80	Same as Cols. 1 - 9

SENSE SWITCH SETTINGS

Switch 1 ON - All values of X and Y will be scaled by multiplying them by the scale factors given on the first card

Switch 1 OFF - Values will be plotted "full scale," that is, each inch on the plot will be equal to 1 unit of the coordinate dimensions. No scale card used.

PROCEDURE

The following sequence of events takes place when using this program:

(1) Load program deck and data deck in card reader, including a scaling card if desired

(2) Push load button on card reader, causing the program to load

(3) Program loading is complete when the typewriter types the message, "Switch 1 On to Scale"

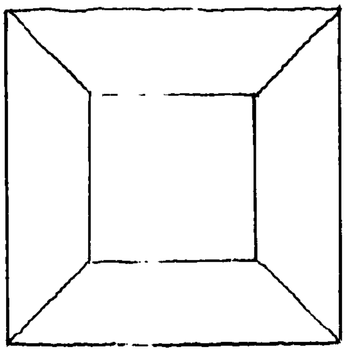
(4) Set the switch as desired, pushing "start" will execute the program

SAMPLE PROBLEM FOR PLOTTING PROGRAM

SAMPLE DATA FOR PLOTTING PROGRAM

.5	.5
2.	2.
6.	2.
6.	6.
2.	6.
2.	2.
3.	3.
6000.	0.
5.	5.
5000.	0.
6.	6.
6000.	0.
6.	2.
5000.	0.
5.	3.
6000.	0.
2.	6.
5000.	0.
3.	5.
5.	5.
5.	3.
3.	3.
3.	5.

FIGURE PLOTTED FROM SAMPLE DATA



USE OF THE SUBROUTINE IN A FORTRAN PROGRAM*

The calling sequence for the plot subroutine is:

```
        X = Any expression
    Dummy = PLOTF (Y)
```

Where:

X = Coordinate X of the point to be plotted. This value must be on the right-hand side of the instruction preceding the plot instruction. This is to place this value in FAC (Floating Point Accumulator).

Y = Coordinate Y of the same point

Dummy = Any floating point dummy variable not used in computation

a. Dummy = PLOTF (11111.) is an instruction that must be placed at the beginning of the program. This will set the subroutine to start, put the pen down, and ready the subroutine for a set of data.

b. Dummy = PLOTF (50000.) will only put the pen down

c. Dummy = PLOTF (60000.) will put the pen up

Instructions b., and c., are complete by themselves and do not require any prior instruction.

Attention is called to the fact that the origin of the plotted figure is automatically set as the first point.

This subroutine can only handle X and Y values having up to three integers (at the moment they are stored in FAC and argument, respectively, ready to be plotted).

*The User should refer to the FORTRAN Manual for the procedure to incorporate this subroutine in the library subroutines deck.

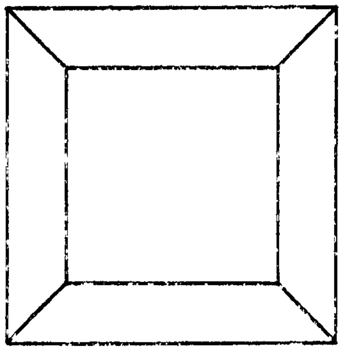
* * * SAMPLE FORTRAN PROGRAM * * *

```
C     SAMPLE PROBLEM FOR PLOT SUBROUTINE
      JULIO=0
C     SET THE PLOT SUBROUTINE TO INITIATE
   10 DUMMY=PLOTF(11111.)
      READ 100,SCALX,SCALY
C     READ IN X AND Y COORDINATES OF THE POINT
   11 READ 100,X,Y
C     CHECK FOR PEN UP OR DOWN
      IF(X-5000.)12,13,14
C     PUT THE PEN DOWN
   13 DUMMY=PLOTF(50000.)
      GO TO 11
C     PUT THE PEN UP
   14 DUMMY=PLOTF(60000.)
      GO TO 11
   12 Y=Y*SCALY
      X=X*SCALX
      DUMMY=PLOTF(Y)
      GO TO 11
  100 FORMAT(8X,F15.8,3X,F15.8)
      END
```

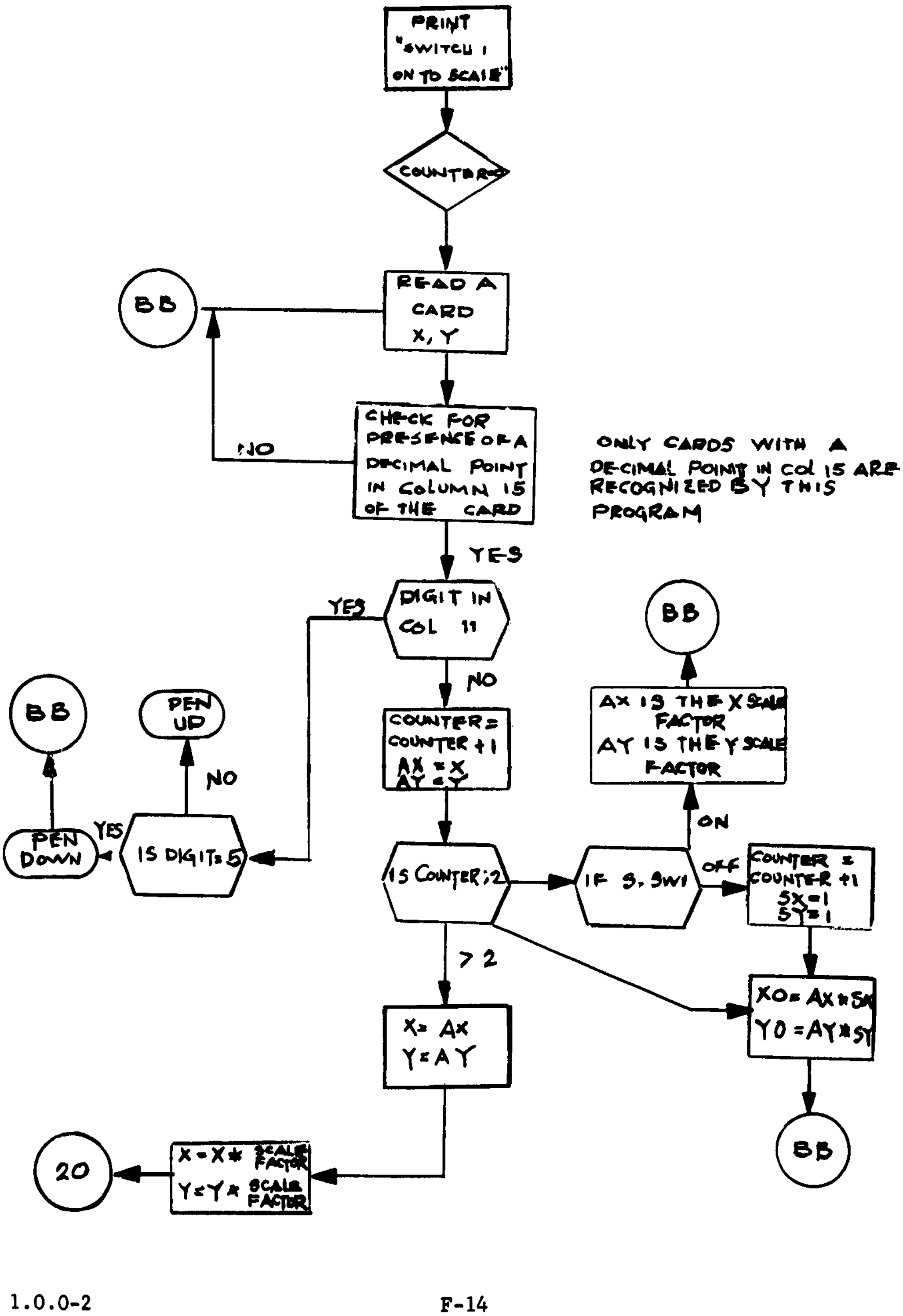
* * * SAMPLE DATA * * *

```
       .5         .5
       2.         2.
       6.         2.
       6.         6.
       2.         6.
       2.         2.
       3.         3.
    6000.         0.
       5.         5.
    5000.         0.
       6.         6.
    6000.         0.
       6.         2.
    5000.         0.
       5.         3.
    6000.         0.
       2.         6.
    5000.         0.
       3.         5.
       5.         5.
       5.         3.
       3.         3.
       3.         5.
```

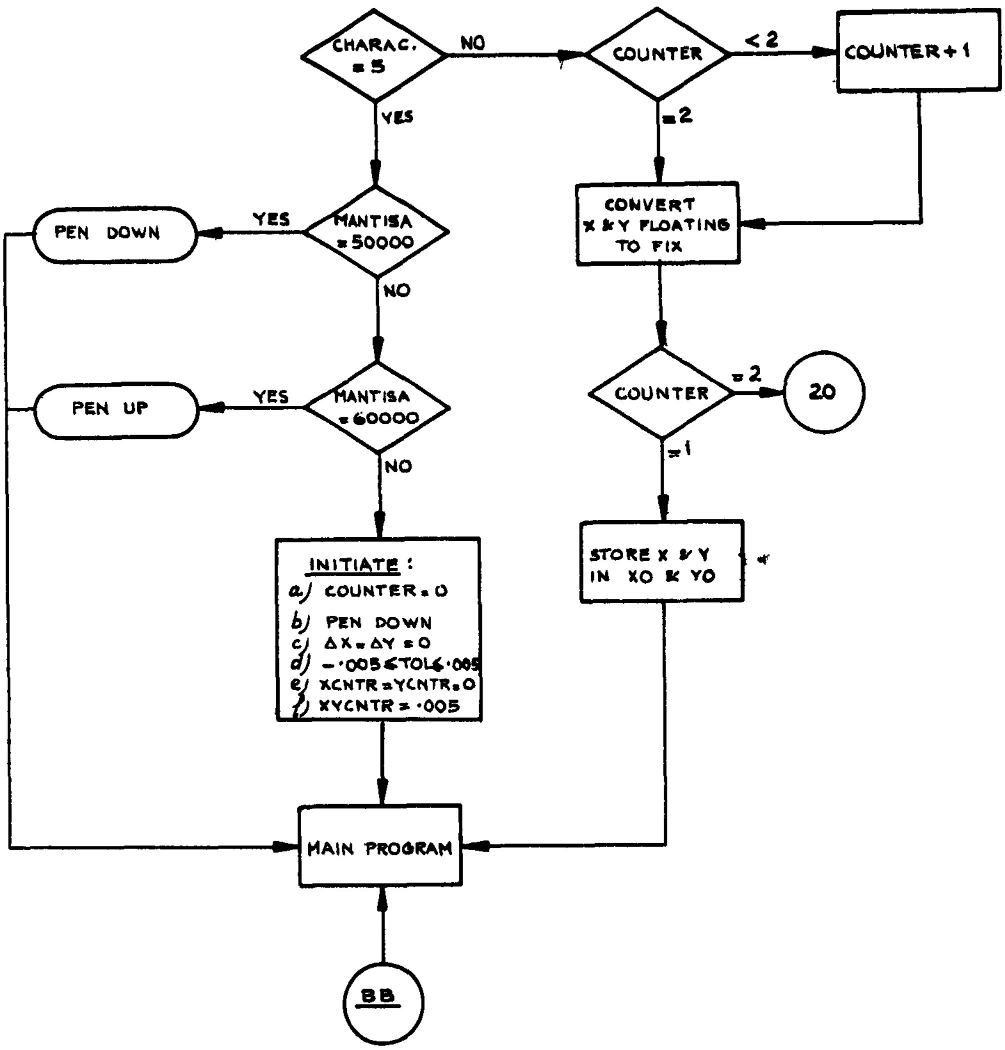
*** SAMPLE OUTPUT ***

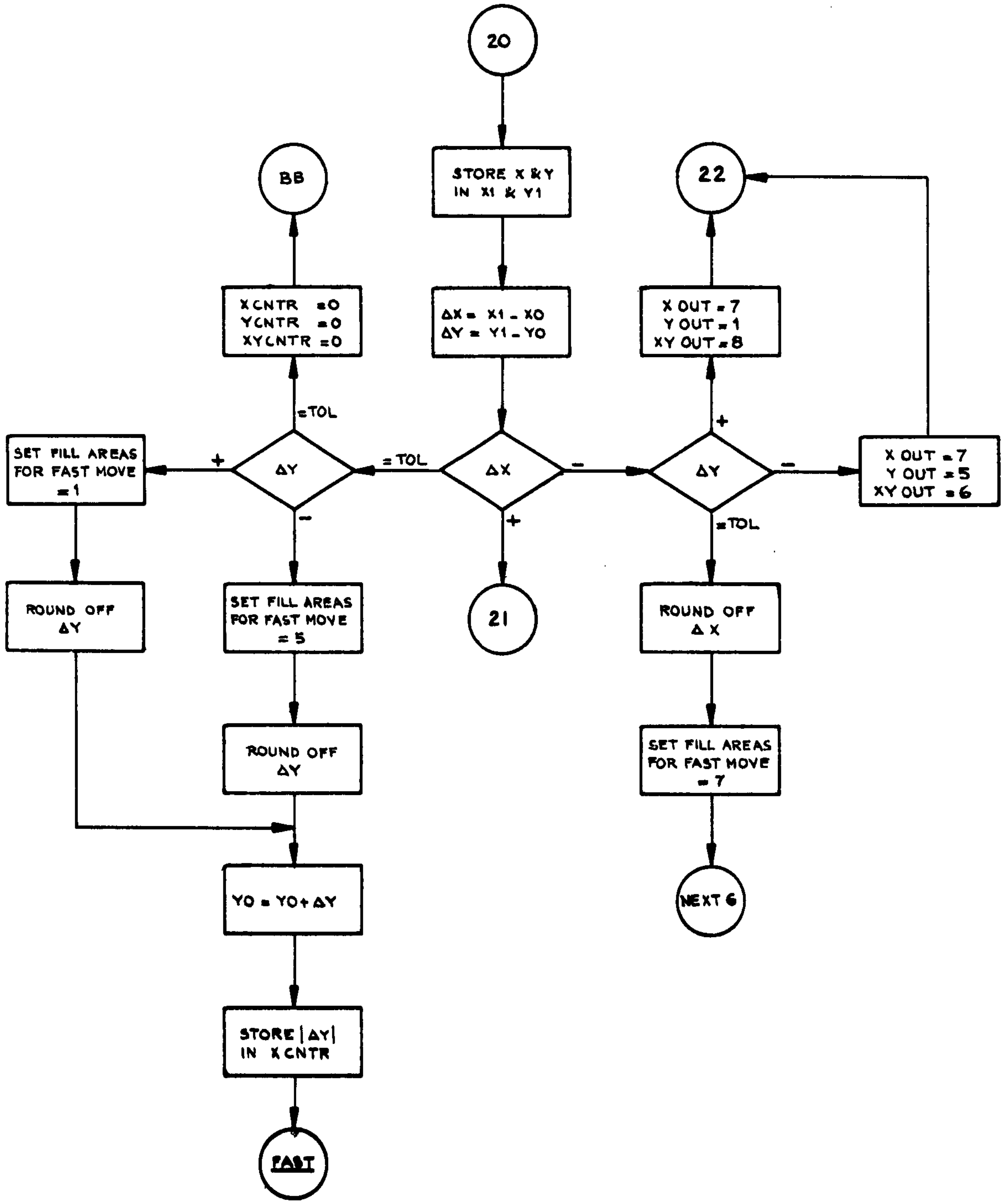


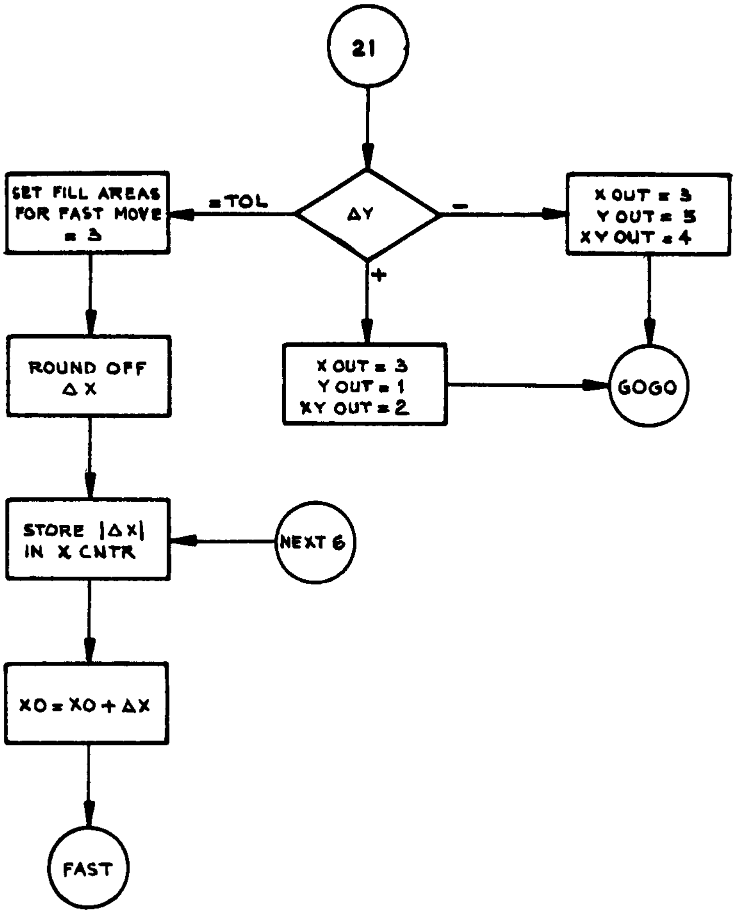
Section IV FLOW DIAGRAM FOR PLOTTING PROGRAM



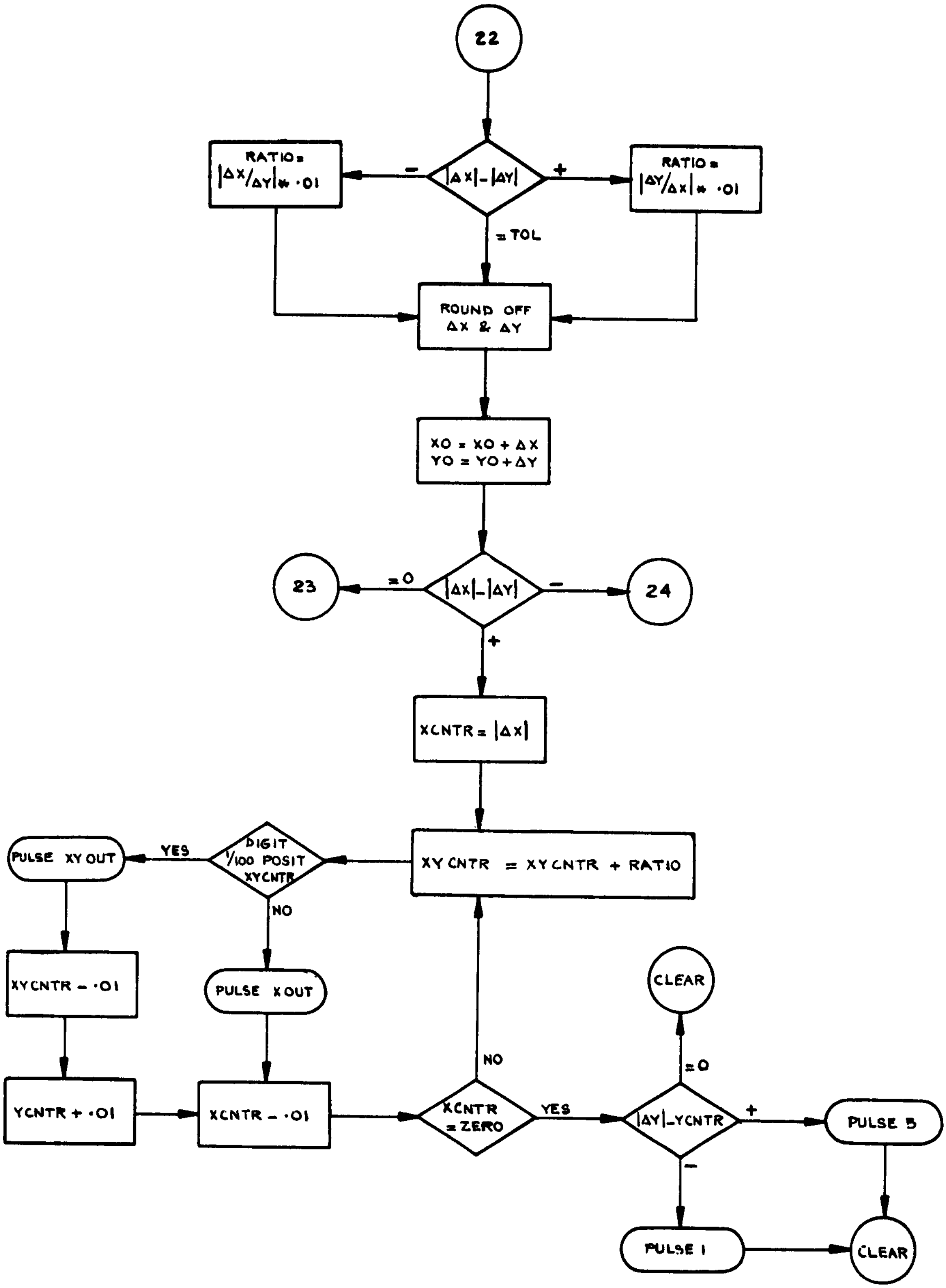
FLOW CHART OF PLOT SUBROUTINE

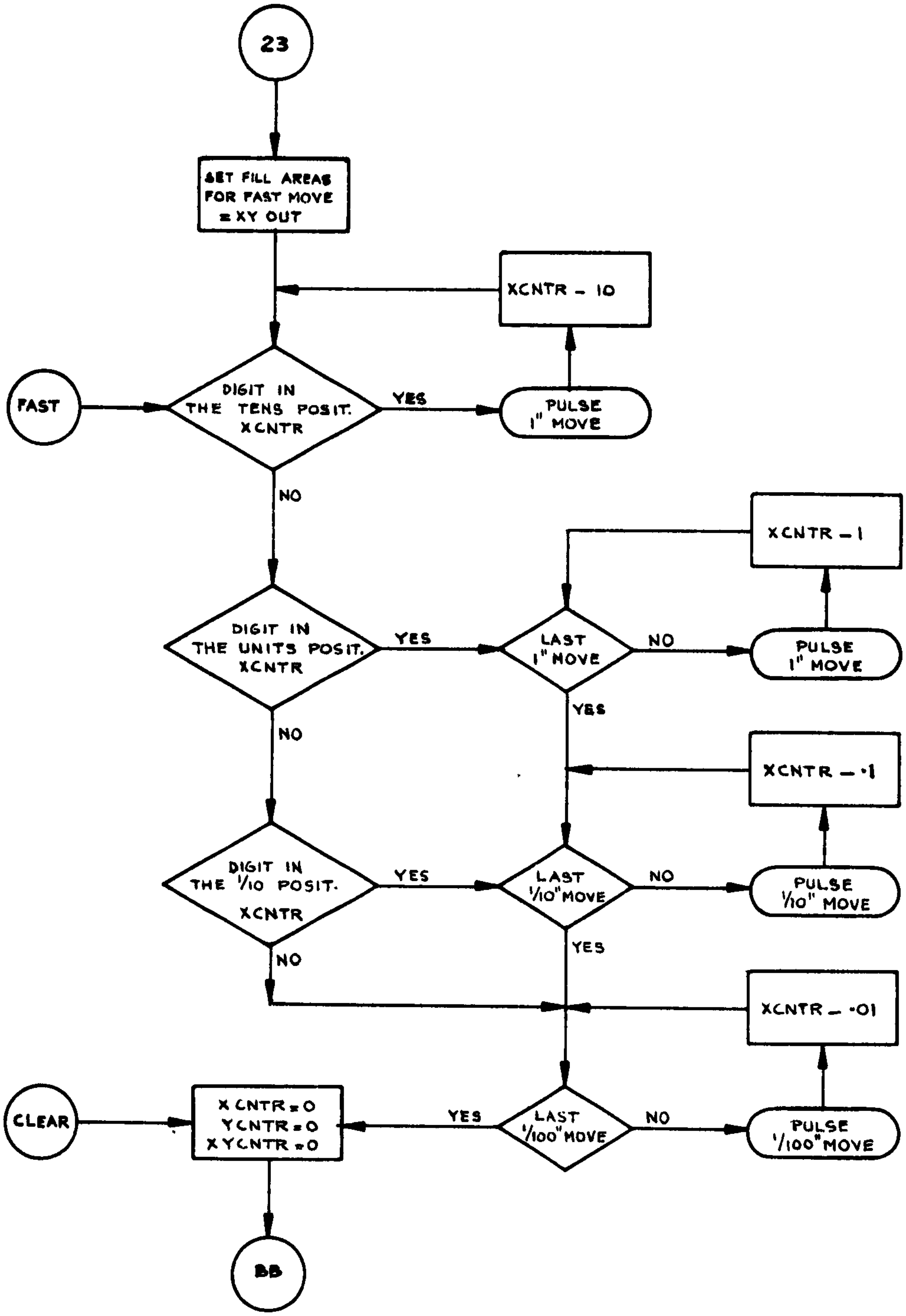


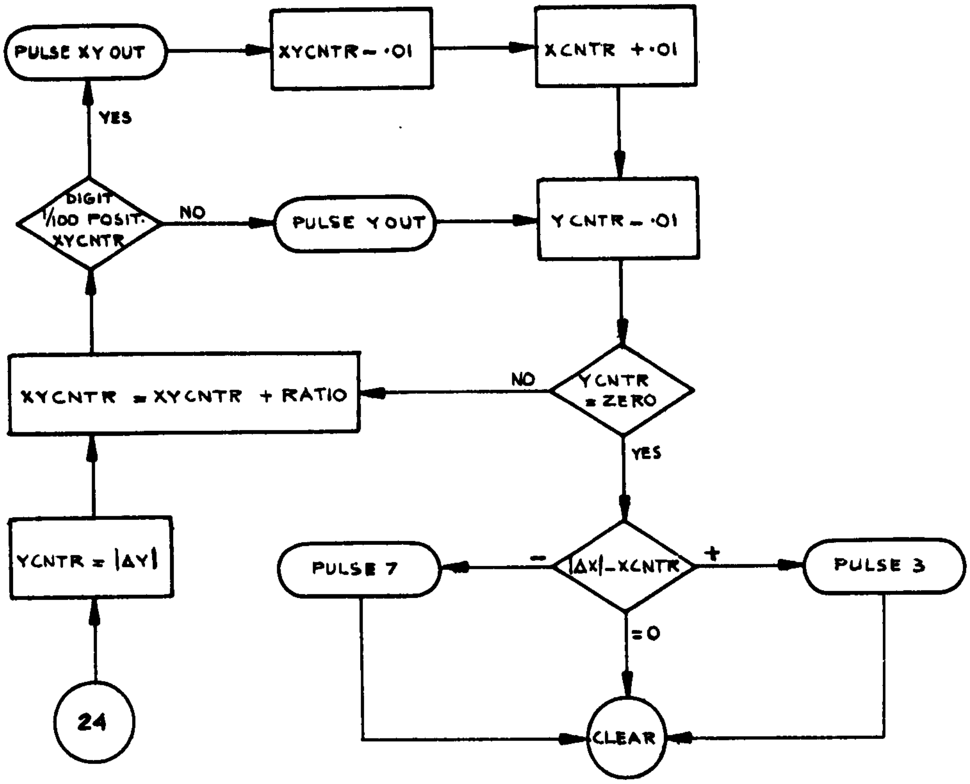

20
STORE X & Y IN X1 & Y1
ΔX = X1 – X0
ΔY = Y1 – Y0
ΔX
ΔY
ΔY
=TOL
=TOL
=TOL
+
–
+
–
+
–
BB
XCNTR =0
YCNTR =0
XYCNTR =0
SET FILL AREAS FOR FAST MOVE =1
ROUND OFF ΔY
SET FILL AREAS FOR FAST MOVE = 5
ROUND OFF ΔY
Y0 = Y0+ΔY
STORE |ΔY| IN XCNTR
FAST
21
22
X OUT = 7
Y OUT = 1
XY OUT = 8
X OUT = 7
Y OUT = 5
XY OUT = 6
ROUND OFF ΔX
SET FILL AREAS FOR FAST MOVE = 7
NEXT 6



21
ΔY
= TOL
−
+
SET FILL AREAS FOR FAST MOVE = 3
X OUT = 3
Y OUT = 5
XY OUT = 4
ROUND OFF ΔX
X OUT = 3
Y OUT = 1
XY OUT = 2
GOGO
STORE |ΔX| IN X CNTR
NEXT 6
XO = XO + ΔX
FAST


22
|ΔX|-|ΔY|
-
+
RATIO= |ΔX/ΔY| * .01
RATIO = |ΔY/ΔX| * .01
= TOL
ROUND OFF ΔX & ΔY
XO = XO + ΔX
YO = YO + ΔY
|ΔX|-|ΔY|
=0
23
-
24
+
XCNTR = |ΔX|
XY CNTR = XY CNTR + RATIO
DIGIT 1/100 POSIT XYCNTR
YES
NO
PULSE XY OUT
XYCNTR - .01
YCNTR + .01
PULSE X OUT
XCNTR - .01
XCNTR = ZERO
NO
YES
|ΔY|-YCNTR
=0
CLEAR
+
PULSE 5
-
PULSE 1
CLEAR


23
SET FILL AREAS FOR FAST MOVE = XY OUT
XCNTR – 10
FAST
DIGIT IN THE TENS POSIT. XCNTR
YES
PULSE 1" MOVE
NO
XCNTR – 1
DIGIT IN THE UNITS POSIT. XCNTR
YES
LAST 1" MOVE
NO
PULSE 1" MOVE
YES
NO
XCNTR – ·1
DIGIT IN THE 1/10 POSIT. XCNTR
YES
LAST 1/10" MOVE
NO
PULSE 1/10" MOVE
YES
NO
XCNTR – ·01
CLEAR
XCNTR = 0
YCNTR = 0
XYCNTR = 0
YES
LAST 1/100" MOVE
NO
PULSE 1/100" MOVE
BB


PULSE XY OUT
XYCNTR – ·01
XCNTR + ·01
YES
DIGIT 1/100 POSIT. XYCNTR
NO
PULSE Y OUT
YCNTR – ·01
NO
YCNTR = ZERO
XYCNTR = XYCNTR + RATIO
YES
YCNTR = |ΔY|
–
|ΔX| – XCNTR
+
PULSE 7
PULSE 3
=0
24
CLEAR

1,0,0-2


```
I-ADD OP                P/L LABEL   OP      OPERANDS

36000720050036002010050044000120027526000590027425000110000026000900026 9  -
2600095002643100000002002600114002742500000000114900012000 00              -
                                *        * *    LINEAR PLOT PROGRAM  -  3/6/63  * *‡
00501                                 DORG  501‡
00505    00005       00089 CO         DS    5‡
00512    00007       00094 AX         DS    7‡
00519    00007       00095 AY         DS    7‡
00526    00007       00097 SX         DS    7‡
00533    00007       00098 SY         DS    7‡
00540    00007       00098 PX         DS    7‡
00547    00007       00099 PY         DS    7‡
00561    00014       00100 CLEER      DC    14,0‡
00100-0000000000000‡                                             -6-0548-0562-
00421    00034       00106 SWITCH DAC   34, PUT SW1 ON TO SCALE. PUSH START.@,421‡
00106-057646300626671005655006356006243415345030057646 2‡       -6-0420-0470-
0010648006263415963030‡                                          -6-0470-0488-
00611    00050       00107 ZEROS      DC    50,0‡
00107-00000000000000000000000000000000000000000000000000‡       -6-0562-0612-
00617    00006       00108 XCNTR      DS    6‡
00623    00006       00109 YCNTR      DS    6‡
00629    00006       00110 XYCNTR     DS    6‡
00637    00008       00111 RATIO      DS    8‡
00643    00006             ZERO1      DC    6,0‡
00000-00000‡                                                     -6-0638-0644-
00649    00006       00113 X0         DS    6‡
00655    00006       00114 Y0         DS    6‡
00661    00006       00115 X1         DS    6‡
00667    00006       00116 Y1         DS    6‡
00717    00050       00117 ONESH      DC    50,11111111111111111111111111111111111111111111111111‡
00117J11111111111111111111111111111111111111111111111111‡       -6-0668-0718-
00767    00050       00118            DC    50,11111111111111111111111111111111111111111111111111‡
00118J11111111111111111111111111111111111111111111111111‡       -6-0718-0768-
00768    00001       00119            DC    1,@‡
00119‡                                                           -6-0768-0769-
00779    00011       00120 ONEST      DC    11,1111111111@‡
00120J1111111111‡                                                -6-0769-0780-
00781    00002       00121 ONESO      DC    2,1@‡
00121J‡                                                          -6-0780-0782-
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I-ADD OP                P/L LABEL    OP       OPERANDS

00831     00050        00122 TWOSH  DC     50,222222222222222222222222222222222222222222222*
00122K22222222222222222222222222222222222222222222222*        -6-0782-0832-
00881     00050        00123        DC     50,222222222222222222222222222222222222222222222*
00123K22222222222222222222222222222222222222222222222*        -6-0832-0882-
00882     00001        00124        DC     1,@*
00124*
                                                              -6-0882-0883-
00893     00011        00125 TWOST  DC     11,2222222222@*
00125K222222222*
                                                              -6-0883-0894-
00895     00002        00126 TWOSO  DC     2,2@*
00126K*
                                                              -6-0894-0896-
00945     00050        00127 THREH  DC     50,333333333333333333333333333333333333333333333*
00127L33333333333333333333333333333333333333333333333*        -6-0896-0946-
00995     00050        00128        DC     50,333333333333333333333333333333333333333333333*
00128L33333333333333333333333333333333333333333333333*        -6-0946-0996-
00996     00001        00129        DC     1,@*
00129*
                                                              -6-0996-0997-
01007     00011        00130 THRET  DC     11,3333333333@*
00130L333333333*
                                                              -6-0997-1008-
01009     00002        00131 THREO  DC     2,3@*
00131L*
                                                              -6-1008-1010-
01059     00050        00132 FOURH  DC     50,444444444444444444444444444444444444444444444*
00132M44444444444444444444444444444444444444444444444*        -6-1010-1060-
01109     00050        00133        DC     50,444444444444444444444444444444444444444444444*
00133M44444444444444444444444444444444444444444444444*        -6-1060-1110-
01110     00001        00134        DC     1,@*
00134*
                                                              -6-1110-1111-
01121     00011        00135 FOURT  DC     11,4444444444@*
00135M444444444*
                                                              -6-1111-1122-
01123     00002        00136 FOURO  DC     2,4@*
00136M*
                                                              -6-1122-1124-
01173     00050        00137 FIVEH  DC     50,555555555555555555555555555555555555555555555*
00137N55555555555555555555555555555555555555555555555*        -6-1124-1174-
01223     00050        00138        DC     50,555555555555555555555555555555555555555555555*
00138N55555555555555555555555555555555555555555555555*        -6-1174-1224-
01224     00001        00139        DC     1,@*
00139*
                                                              -6-1224-1225-
01235     00011        00140 FIVET  DC     11,5555555555@*
00140N555555555*
                                                              -6-1225-1236-
```

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1,0,0-2

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I-ADD OP              P/L LABEL    OP       OPERANDS

01237    00002       00141 FIVEO  DC     2,5@#
00141N#                                                          -6-1236-1238-
01287    00050       00142 SIXSH  DC     50,6666666666666666666666666666666666666666666666#
001420666666666666666666666666666666666666666666666#             -6-1238-1288-
01337    00050       00143        DC     50,6666666666666666666666666666666666666666666666#
001430666666666666666666666666666666666666666666666#             -6-1288-1338-
01338    00001       00144        DC     1,@#
00144#                                                           -6-1338-1339-
01349    00011       00145 SIXST  DC     11,6666666666@#
001450666666666#                                                 -6-1339-1350-
01351    00002       00146 SIXSO  DC     2,6@#
001460#                                                          -6-1350-1352-
01401    00050       -0147 SEVSH  DC     50,7777777777777777777777777777777777777777777777#
00147P777777777777777777777777777777777777777777777#             -6-1352-1402-
01451    00050       00148        DC     50,7777777777777777777777777777777777777777777777#
00148P777777777777777777777777777777777777777777777#             -6-1402-1452-
01452    00001       00149        DC     1,@#
00149#                                                           -6-1452-1453-
01463    00011       00150 SEVST  DC     11,7777777777@#
00150P777777777#                                                 -6-1453-1464-
01465    00002       00151 SEVSO  DC     2,7@#
00151P#                                                          -6-1464-1466-
01515    00050       00152 EIGHH  DC     50,8888888888888888888888888888888888888888888888#
00152Q888888888888888888888888888888888888888888888#             -6-1466-1516-
01565    00050       00153        DC     50,8888888888888888888888888888888888888888888888#
00153Q888888888888888888888888888888888888888888888#             -6-1516-1566-
01566    00001       00154        DC     1,@#
00154#                                                           -6-1566-1567-
01577    00011       00155 EIGHT. DC     11,8888888888@#
00155Q888888888#                                                 -6-1567-1578-
01579    00002       00156 EIGHO  DC     2,8@#
00156Q#                                                          -6-1578-1580-
01585    00006       00157 DELTAX DS     6#
01591    00006       00158 DELTAY DS     6#
01597    00006       4480  ABSDX  DS     6,,,                 ABSOLUTE VALUE OF DELTAX#
01603    00006       4490  ABSDY  DS     6,,,                 ABSOLUTE VALUE OF DELTAY#
01606    00003       00159 PENDWN DC     3,0@#
00159-0#                                                         -6-1604-1607-
```

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 I-ADD OP                P/L LABEL   OP       OPERANDS

01609    00003        4520  PENUP  DC     3,9@‡
45200-9‡                                                    -6-1607-1610-
01612    00003        4630  TOLER  DC     3,5,,             TOLERENCE OF .005 INCH‡
46300-05‡                                                   -6-1610-1613-
01614 34 00000 00102 10000 START  RCTY    ‡
01626 39 00423 00100 10001        WATY   SWITCH&2‡
01638 48 00000 00000 10005        H       ‡
01650 49 03000 00000 10026        B      3000‡
03000                10030        DORG   3000‡
03000 26 00505 00552 10035        TF     CO,CLEER-9‡
03012 38 01605 00200 10037 PEND   WNPT   PENDWN-1‡
03024 37 09995 00500 10040 BEG    RACD   9995‡
03036 25 00002 10023 10041        TD     2,10023‡
03048 25 00001 10022 10042        TD     1,10022‡
03060 32 00001 00000 10043        SF     1‡
03072 14 00002 000-3 10044        CM     2,3,10,            CHECK FOR DEC. POINT IN COL. 15‡
03084 47 03024 01200 10045        BNE    BEG‡
03096 43 03348 10015 10036        BD     JULIO,10015,,      CHECK FOR PEN UP OR DOWN‡
03108 26 00519 00561 10046        TF     AY,CLEER‡
03120 32 00509 00000 10050        SF     AX-3‡
03132 72 10029 00512 10055        TNS    10029,AX‡
03144 32 00507 00000              SF     AX-5‡
03156 72 10021 00509 10065        TNS    10021,AX-3‡
03168 43 03444 10012 10070        BD     FAX,10012‡
03180 32 00516 00000 10075 MISS   SF     AY-3‡
03192 72 10065 00519 10080        TNS    10065,AY‡
03204 32 00514 00000 10085        SF     AY-5‡
03216 72 10057 00516 10090        TNS    10057,AY-3‡
03228 43 03468 10048 10095        BD     FAY,10048‡
03240 14 00505 000-3 10096        CM     CO,3,10‡
03252 46 03276 01100 10097        BP     *&24‡
03264 11 00505 000-1 10100 G      AM     CO,1,10‡
03276 46 03492 00100 10105        BC1    SCALE‡
03288 14 00505 -0001 10110        CM     CO,1,7‡
03300 46 03408 01100 10115        BP     GABOR‡
03312 26 00649 00512 10120        TF     XO,AX‡
03324 26 00655 00519 10125        TF     YO,AY‡
03336 49 03024 00000 10130        B      BEG‡
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1.0.0:2

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I-ADD OP                 P/L LABEL   OP      OPERANDS

03348 32 10014 00000 10131 JULIO  SF    10014‡
03360 14 10015 000P5 10132        CM    10015,75,10,        CHECK FOR PEN DOWN‡
03372 46 03012 01200 10133        BE    PEND‡
03384 38 01608 00200 10134        WNPT  PENUP-1‡
03396 49 03024 00000 10135        B     BEG‡
03408 26 00661 00512 10140 GABOR  TF    X1,AX‡
03420 26 00667 00519 10145        TF    Y1,AY‡
03432 49 03768 00000 10150        B     NEXT1‡
03444 32 00512 00000 10155 FAX    SF    AX‡
03456 49 03180 00000 10160        B     MISS‡
03468 32 00519 00000 10165 FAY    SF    AY‡
03480 49 03264 00000 10170        B     G‡
03492 14 00505 -0002 20000 SCALE  CM    C0,2,7‡
03504 46 03672 01100 20005        BP    ALL‡
03516 46 03564 01200 20010        BE    FIRST‡
03528 26 00526 00512 20015        TF    SX,AX‡
03540 26 00533 00519 20020        TF    SY,AY‡
03552 49 03024 00000 20025        B     BEG‡
03564 23 00512 00526 20030 FIRST  M     AX,SX‡
03576 71 00096 00099 20031        MF    96,99‡
03588 32 00091 00000 20035        SF    91‡
03600 26 00649 00096 20040        TF    X0,96‡
03612 23 00519 00533 20045        M     AY,SY‡
03624 71 00096 00099 20046        MF    96,99‡
03636 32 00091 00000 20050        SF    91‡
03648 26 00655 00096 20055        TF    Y0,96‡
03660 49 03024 00000 20060        B     BEG‡
03672 23 00512 00526 20065 ALL    M     AX,SX‡
03684 71 00096 00099 20066        MF    96,99‡
03696 32 00091 00000 20070        SF    91‡
03708 26 00661 00096 20075        TF    X1,96‡
03720 23 00519 00533 20080        M     AY,SY‡
03732 71 00096 00099 20081        MF    96,99‡
03744 32 00091 00000 20085        SF    91‡
03756 26 00667 00096 20090        TF    Y1,96‡
03768 K0 01585 00661 1660  NEXT1  TF    DELTAX,X1,01‡
03780 KK 01585 00649 1670         S     DELTAX,X0,01,       TOTAL INCREMENT IN THE X DIRECTION‡
03792 K0 01597 01585 1680         TF    ABSDX,DELTAX,01‡
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1.0.0-2

```
I-ADD OP                  P/L LABEL   OP       OPERANDS

03804 L3 01597 00000 1690             CF      ABSDX,,0‡
03816 KO 01591 00667 1700             TF      DELTAY,Y1,01‡
03828 KK 01591 00655 1710             S       DELTAY,Y0,01,       TOTAL INCREMENT IN THE Y DIRECTION‡
03840 KO 01603 01591 1720             TF      ABSDY,DELTAY,01‡
03852 L3 01603 00000 1730             CF      ABSDY,,0‡
03864 KM 01597 01612 1740             C       ABSDX,TOLER,01,     TEST FOR ABSDX LESS THAN .005‡
03876 M6 03900 01100 1750             BP      *&24,,0‡
03888 M9 05604 00000 1760             B       NEXT5,,0‡
03900 KM 01585 00643 1770             C       DELTAX,ZERO1,01,    TEST FOR DELTAX # 0‡
03912 M6 04104 01100 1780             BP      NEXT2,,0‡
03924 KM 01603 01612 1790             C       ABSDY,TOLER,01,     TEST FOR ABSDY LESS THAN .005‡
03936 M6 03960 01100 1800             BP      *&24,,0‡
03948 M9 05856 00000 1810             B       NEXT6,,0‡
03960 KM 01591 00643 1820             C       DELTAY,ZERO1,01,    TEST FOR DELTAY # 0‡
03972 M6 04044 01100 1830             BP      NEXT3,,0‡
                     1840  * -NEG     ATIV    E DELTAX AND DELTAY-‡
03984 JO 04410 -1464 1850             TFM     XOUT,SEVSO-1,017‡
03996 JO 04782 -1236 1860             TFM     YOUT,FIVEO-1,017‡
04008 JO 04638 -1350 1870             TFM     XYOUT,SIXSO-1,017‡
04020 JO 05010 -1350 1880             TFM     GOXY2&6,SIXSO-1,017‡
04032 M9 04272 00000 1890             B       GOGO,,0‡
                     1900  * -NEG     ATIV    E DELTAX AND POSITIVE DELTA Y-‡
04044 JO 04410 -1464 1910  NEXT3      TFM     XOUT,SEVSO-1,017‡
04056 JO 04782 -0780 1920             TFM     YOUT,ONESO-1,017‡
04068 JO 04638 -1578 1930             TFM     XYOUT,EIGHO-1,017‡
04080 JO 05010 -1578 1940             TFM     GOXY2&6,EIGHO-1,017‡
04092 M9 04272 00000 1950             B       GOGO,,0‡
                     1960  * -POS     ITIV    E DELTAX-‡
04104 KM 01603 01612 1970  NEXT2      C       ABSDY,TOLLR,01,     TEST FOR ABSDY LESS THAN .005‡
04116 M6 04140 01100 1980             BP      *&24,,0‡
04128 M9 05856 00000 1990             B       NEXT6,,0‡
04140 KM 01591 00643 2000             C       DELTAY,ZERO1,01,    TEST FOR DELTAY # 0‡
04152 M6 04224 01100 2010             BP      NEXT4,,0‡
                     2020  * -POS     ITIV    E DELTAX AND NEGATIVE DELTAY-‡
04164 JO 04410 -1008 2030             TFM     XOUT,THREO-1,017‡
04176 JO 04782 -1236 2040             TFM     YOUT,FIVEO-1,017‡
04188 JO 04638 -1122 2050             TFM     XYOUT,FOURO-1,017‡
04200 JO 05010 -1122 2060             TFM     GOXY2&6,FOURO-1,017‡
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1.0.0-2

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I-ADD OP                 P/L LABEL   OP      OPERANDS

04212 M9 04272 00000 2070            B       GOGO,,0‡
                     2080  * -POS ITIV  E DELTAX AND DELTAY-‡
04224 JO 04410 -1008 2090  NEXT4  TFM    XOUT,THREO-1,017‡
04236 JO 04782 -0780 2100         TFM    YOUT,ONESO-1,017‡
04248 JO 04638 -0894 2110         TFM    XYOUT,TWOSO-1,017‡
04260 JO 05010 -0894 2120         TFM    GOXY2&6,TWOSO-1,017‡
04272 KM 01597 01603 2180  GOGO   C      ABSDX,ABSDY,01,    TEST FOR BIGGER INCREMENT‡
04284 M6 05052 01200 2190         BE     OK,,0‡
04296 M7 04680 01300 2200         BN     YBIGER,,0‡
                     2210  * -DEL TAX   GREATER THAN DELTAY-‡
04308 2Q 00096 01603 2220         LD     96,ABSDY,1‡
04320 2R 00097 01597 2230         D      97,ABSDX,1‡
04332 32 00091 00000 2240         SF     91‡
04344 K6 00637 00093 2250         TF     RATIO,93,0,        RATIO DELTAY/DELTAX‡
04356 M9 05052 00000 2260         B      OK,,0‡
                     2270  * -DEL TAX   GREATER THAN DELTAY-‡
04368 KO 00617 01584 2280         TF     XCNTR,DELTAX-1,01, SET XCOUNTER EQUAL TO DELTAX‡
04380 KJ 00629 00637 2290  G02    A      XYCNTR,RATIO,01,   MODIFY XYCOUNTER ADDING RATIO‡
04392 ML 04632 00626 2300         BD     GOXY1,XYCNTR-3,01, TEST FOR DIGIT IN XYCOUNTER‡
04404 38 00000 00200 2310         WNPT    ‡
04410    00005       2320  XOUT   DS     5,*-5‡
04416 J2 00617 000-1 2330  G03    SM     XCNTR,1,010‡
04428 J4 00617 -0000 2340         CM     XCNTR,0,07,        TEST FOR LAST MOVE‡
04440 M6 04380 01100 2350         BP     G02,,0‡
                     2360  * -FIN AL A  DJUSTMENT IN THE Y DIRECTION-‡
04452 MM 04548 01591 2370         BNF    *&96,DELTAY,01,    TEST FOR NEGATIVE DELTAY‡
                     2380  * -NEG ATIV  E DELTAY-‡
04464 KM 01590 00622 2390         C      DELTAY-1,YCNTR-1,01,TEST FOR FINAL ADJUSTMENT‡
04476 M6 05220 01200 2400         BE     CLEAR,,0‡
04488 M7 04524 01300 2410         BN     *&36,,0‡
04500 L8 01236 00200 2420         WNPT   FIVEO-1,,0‡
04512 M9 05220 00000 2430         B      CLEAR,,0‡
04524 L8 00780 00200 2440         WNPT   ONESO-1,,0‡
04536 M9 05220 00000 2450         B      CLEAR,,0‡
                     2460  * -POS ITIV  E DELTAY-‡
04548 KM 01590 00622 2470         C      DELTAY-1,YCNTR-1,01,TEST FOR FINAL ADJUSTMENT‡
04560 M6 052[illegible] 01200 2480         BE     CLEAR,,0‡
04572 M7 046[illegible] 01300 2490         BN     *&36,,0‡
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I-ADD OP                 P/L LABEL   OP       OPERANDS

04584 L8 00780 00200 2500             WNPT   ONESO-1,,0‡
04596 M9 05220 00000 2510             B      CLEAR,,0‡
04608 L8 01236 00200 2520             WNPT   FIVEO-1,,0‡
04620 M9 05220 00000 2530             B      CLEAR,,0‡
                     2540  * -DIG IT I    N XYCOUNTER %DELTAX GRATER THAN DELTAY□-‡
04632 38 00000 00200 2550  GOXY1      WNPT    ‡
04638    00005       2560  XYOUT      DS     5,*-5‡
04644 J2 00629 0J000 2570             SM     XYCNTR,1000,08‡
04656 J1 00623 000J0 2580             AM     YCNTR,10,010‡
04668 M9 04416 00000 2590             B      GO3,,0‡
                     2600  * -DEL     TAY    LARGER THAN DELTAX-‡
04680 2Q 00096 01597 2610  YBIGER     LD     96,ABSDX,1‡
04692 2R 00097 01603 2620             D      97,ABSDY,1‡
04704 32 00091 00000 2630             SF     91‡
04716 K6 00637 00093 2640             TF     RATIO,93,0‡
04728 M9 05052 00000 2650             B      OK,,0‡
                     2660  * DELT     AY L   ARGER THAN DELTAX‡
04740 K0 00623 01590 2670             TF     YCNTR,DELTAY-1,01, SET YCOUNTER EQUAL TO DELTAY‡
04752 KJ 00629 00637 2680  GO4        A      XYCNTR,RATIO,01,   MODIFY XYCOUNTER ADDING RATIO‡
04764 ML 05004 00626 2690             BD     GOXY2,XYCNTR-3,01, TEST FOR DIGIT IN XYCOUNTER‡
04776 38 00000 00200 2700             WNPT    ‡
04782    00005       2710  YOUT       DS     5,*-5‡
04788 J2 00623 000-1 2720  GO5        SM     YCNTR,1,010‡
04800 J4 00623 -0000 2730             CM     YCNTR,0,07,        TEST FOR LAST MOVE‡
04812 M6 04752 01100 2740             BP     GO4,,0‡
                     2750  * -FIN     AL A   DJUSTMENT IN THE X DIRECTION-‡
04824 MM 04920 01585 2760             BNF    *&96,DELTAX,01,    TEST FOR NEGATIVE DELTAX‡
                     2770  * -NEG     ATIV   E DELTAX-‡
04836 KM 01584 00616 2780             C      DELTAX-1,XCNTR-1,01,TEST FOR FINAL ADJUSTMENT‡
04848 M6 05220 01200 2790             BE     CLEAR,,0‡
04860 M7 04896 01300 2800             BN     *&36,,0‡
04872 L8 01464 00200 2810             WNPT   SEVSO-1,,0‡
04884 M9 05220 00000 2820             B      CLEAR,,0‡
04896 L8 01008 00200 2830             WNPT   THREO-1,,0‡
04908 M9 05220 00000 2840             B      CLEAR,,0‡
                     2850  * -POS     ITIV   E DELTAX-‡
04920 KM 01584 00616 2860             C      DELTAX-1,XCNTR-1,01,TEST FOR FINAL ADJUSTMENT‡
04932 M6 05220 01200 2870             BE     CLEAR,,0‡
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1.0.0-2

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I-ADD OP                P/L LABEL   OP     OPERANDS

04944 M7 04980 01300 2880           BN     *&36,,0‡
04956 L8 01008 00200 2890           WNPT   THREO-1,,0‡
04968 M9 05220 00000 2900           B      CLEAR,,0‡
04980 L8 01464 00200 2910           WNPT   SEVSO-1,,0‡
04992 M9 05220 00000 2920           B      CLEAR,,0‡
                     2930 * -DIG    IT I   N XYCOUNTER %DELTAY LARGER THAN DELTAX□-‡
05004 38 00000 00200 2940 GOXY2     WNPT    ‡
05016 J2 00629 -1000 2950           SM     XYCNTR,1000,07‡
05028 J1 00617 00010 2960           AM     XCNTR,10,010‡
05040 M9 04788 00000 2970           B      G05,,0‡
                     2980 * -DEL    TAX    EQUAL TO DELTAY-‡
05052 PJ 01582 01585 2990 OK        MF     DELTAX-3,DELTAX,01‡
05064 J1 01585 000-5 3000           AM     DELTAX,5,010,       ROUND OFF DELTAX‡
05076 J5 01585 00000 3010           TDM    DELTAX,0,0‡
05088 PJ 01585 01582 3020           MF     DELTAX,DELTAX-3,01‡
05100 KJ 00649 01585 3030           A      X0,DELTAX,01,       ADJUST X0‡
05112 PJ 01588 01591 3040           MF     DELTAY-3,DELTAY,01‡
05124 J1 01591 000-5 3050           AM     DELTAY,5,010,       ROUND OFF DELTAY‡
05136 J5 01591 00000 3060           TDM    DELTAY,0,0‡
05148 PJ 01591 01588 3070           MF     DELTAY,DELTAY-3,01‡
05160 KJ 00655 01591 3080           A      Y0,DELTAY,01,       ADJUST Y0‡
05172 KM 01584 01590 3090           C      DELTAX-1,DELTAY-1,01,TEST FOR LARGER INCREMENT‡
05184 M7 04740 01300 3100           BN     G04-12,,0‡
05196 M6 05268 01200 3110           BE     XYGO,,0‡
05208 M9 04368 00000 3120           B      G02-12,,0‡
                     3130 * -CLE    AR X   COUNTER AND YCOUNTER TO ZEROS AND SET XYCOUNTER #.005 -‡
05220 J6 00629 -0005 3140 CLEAR     TFM    XYCNTR,5,07‡
05232 K0 00617 00643 3150           TF     XCNTR,ZERO1,01‡
05244 K0 00623 00643 3160           TF     YCNTR,ZERO1,01‡
05256 49 03024 00000 3170           B      BEG‡
                     3180 * DELT    AX E   QUAL TO DELTAY‡
05268 K0 05418 04638 3190 XYGO      TF     FILL1,XYOUT,01‡
05280 J2 04638 00011 3200           SM     XYOUT,11,010‡
05292 K0 05478 04638 3210           TF     FILL2,XYOUT,01‡
05304 J2 04638 00101 3220           SM     XYOUT,101,09‡
05316 K0 05538 04638 3230           TF     FILL3,XYOUT,01‡
05328 K0 05586 04638 3240           TF     FILL4,XYOUT,01‡
05340 K0 00616 01584 3250           TF     XCNTR-1,DELTAX-1,01,SET XCOUNTER EQUAL TO DELTAX‡
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I-ADD OP                    P/L LABEL    OP       OPERANDS

05352 ML 05568 00613 3260  FAST    BD    TENS,XCNTR-4,01,    TEST FOR DIGIT IN THE TENS POSITION‡
05364 ML 05508 00614 3270          BD    UNITS,XCNTR-3,01,   TEST FOR DIGIT IN THE UNITS POSIT.‡
05376 ML 05448 00615 3280          BD    TENTHS,XCNTR-2,01,  TEST FOR DIGIT IN THE 1/10 POSIT.‡
05388 J4 00616 -0000 3290  LAST    CM    XCNTR-1,0,07,       TEST FOR LAST SINGLE MOVE‡
05400 M7 05220 01100 3300          BNP   CLEAR,,0‡
05412 38 00000 00200 3310          WNPT   ‡
05418    00005       3320  FILL1   DS    5,*-5‡
05424 J2 00616 000-1 3330          SM    XCNTR-1,1,010‡
05436 M9 05388 00000 3340          B     LAST,,0‡
05448 J4 00615 0-000 3350  TENTHS  CM    XCNTR-2,0,08,       TEST FOR LAST 1/10 INCH MOVE‡
05460 M7 05388 01100 3360          BNP   LAST,,0‡
05472 38 00000 00200 3370          WNPT   ‡
05478    00005       3380  FILL2   DS    5,*-5‡
05484 J2 00615 000-1 3390          SM    XCNTR-2,1,010‡
05496 M9 05448 00000 3400          B     TENTHS,,0‡
05508 J4 00614 00-00 3410  UNITS   CM    XCNTR-3,0,09,       TEST FOR LAST ONE INCH MOVE‡
05520 M7 05448 01100 3420          BNP   TENTHS,,0‡
05532 38 00000 00200 3430          WNPT   ‡
05538    00005       3440  FILL3   DS    5,*-5‡
05544 J2 00614 000-1 3450          SM    XCNTR-3,1,010‡
05556 M9 05508 00000 3460          B     UNITS,,0‡
05568 J2 00614 000-1 3470  TENS    SM    XCNTR-3,1,010‡
05580 38 00000 00200 3480          WNPT   ‡
05586    00005       3490  FILL4   DS    5,*-5‡
05592 M9 05352 00000 3500          B     FAST,,0‡
                     3510  * -DEL  TAX   EQUAL ZERO-‡
05604 KM 01603 01612 3520  NEXT5   C     ABSDY,TOLER,01,     TEST FOR ABSDY LESS THAN .005‡
05616 M6 05640 01100 3530          BP    *&24,,0‡
05628 M9 05220 00000 3540          B     CLEAR,,0‡
05640 KM 01591 00643 3550          C     DELTAY,ZERO1,01,    TEST FOR DELTAY EQUAL ZERO‡
05652 M6 05748 01100 3560          BP    NEXT55,,0‡
                     3570  * -DEL  TAX   EQUAL ZERO AND NEGATIVE DELTAY-‡
05664 J0 05418 -1236 3580          TFM   FILL1,FIVEO-1,017‡
05676 J0 05478 -1225 3590          TFM   FILL2,FIVET-10,017‡
05688 J0 05538 -1124 3600          TFM   FILL3,FIVEH-49,017‡
05700 J0 05586 -1124 3610          TFM   FILL4,FIVEH-49,017‡
05712 J2 01591 000-5 3620          SM    DELTAY,5,010,       ROUND OFF DELTAY‡
05724 J5 01591 0000- 3630          TDM   DELTAY,,011‡
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I-ADD OP                P/L LABEL   OP      OPERANDS

05736 M9 05820 00000 3640           B      NEXTY,,0‡
                     3650  * -DEL TAX      EQUAL ZERO AND POSITIVE DELTAY-‡
05748 J0 05418 -0780 3660  NEXT55 TFM      FILL1,ONESO-1,017‡
05760 J0 05478 -0769 3670         TFM      FILL2,ONEST-10,017‡
05772 J0 05538 -0668 3680         TFM      FILL3,ONESH-49,017‡
05784 K0 05586 05538 3690         TF       FILL4,FILL3,01‡
05796 J1 01591 000-5 3700         AM       DELTAY,5,010,      ROUND OFF DELTAY‡
05808 J5 01591 00000 3710         TDM      DELTAY,0,0‡
05820 K0 00616 01590 3720  NEXTY  TF       XCNTR -1,DELTAY-1,01,SET XCOUNTER EQUAL TO DELTAY‡
05832 KJ 00655 01591 3730         A        Y0,DELTAY,01,      ADJUST Y0‡
05844 M9 05352 00000 3740         B        FAST,,0‡
                     3750  * -DEL TAY      EQUAL ZERO-‡
05856 MM 05976 01585 3760  NEXT6  BNF      NEXT66,DELTAX,01,  TEST FOR NEGATIVE DELTAX‡
                     3770  * -DEL TAY      EQUAL ZERO AND NEGATIVE DELTAX-‡
05868 J2 01585 000-5 3780         SM       DELTAX,5,010,      ROUND OFF DELTAX‡
05880 J5 01585 0000- 3790         TDM      DELTAX,0,011‡
05892 J0 05418 -1464 3800         TFM      FILL1,SEVSO-1,017‡
05904 J0 05478 -1453 3810         TFM      FILL2,SEVST-10,017‡
05916 J0 05538 -1352 3820         TFM      FILL3,SEVSH-49,017‡
05928 K0 05586 05538 3830         TF       FILL4,FILL3,01‡
05940 K0 00616 01584 3840         TF       XCNTR-1,DELTAX-1,01,SET XCOUNTER EQUAL TO DELTAX‡
05952 KJ 00649 01585 3850         A        X0,DELTAX,01,      ADJUST X0‡
05964 M9 05352 00000 3860         B        FAST,,0‡
                     3870  * -DEL TAY      EQUAL ZERO AND POSITIVE DELTAX-‡
05976 J0 05418 -1008 3880  NEXT66 TFM      FILL1,THREO-1,017‡
05988 J0 05478 -0997 3890         TFM      FILL2,THRET-10,017‡
06000 J0 05538 -0896 3900         TFM      FILL3,THREH-49,017‡
06012 K0 05586 05538 3910         TF       FILL4,FILL3,01‡
06024 J1 01585 000-5 3920         AM       DELTAX,5,010,      ROUND OFF DELTAX‡
06036 J5 01585 00000 3930         TDM      DELTAX,0,0‡
06048 K0 00616 01584 3940         TF       XCNTR-1,DELTAX-1,01,SET XCOUNTER EQUAL TO DELTAX‡
06060 KJ 00649 01585 3950         A        X0,DELTAX,01,      ADJUST X0‡
06072 M9 05352 00000 3960         B        FAST,,0‡
01614                20905        DEND     START‡
20905  L600000005004900000‡                                -8-0096-0115-
3600100005003600172005003600244005003600316005003600000000500          -
00000000000102030400020406080003060902100408021610050015102006021814200‡ -
70411282008061422300908172630000000000506070809001214161815181124272024‡ -
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I-ADD OP               P/L LABEL   OP       OPERANDS

82236352035304540363248445532494653604846546275445362718012345678912345 6# -
789-23456789-J3456789-JK456789-JKL56789-JKLM6789-JKLMN789-JKLMN089-JKLMN# -
M80000000000049-16140P9-JKLMNOPQ#     L100388000019M90000000000M90003600000  -
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I-ADD OP                P/L LABEL   OP       OPERANDS

360007200500360020100500440001200275260005900274250001100000260009000269  -
2600095002643100000002002600114002742500000000114900012000000             -
                        0001  *   PL OT S  UBROUTINE - FORTRAN FORMAT   12/14/62‡
05000                   0010            DORG  5000‡
05000 K6 05023 59829 0020            TF    BOX,ARG,0,           STORE ADRESS OF THE ARGUMENT IN BOX‡
05012 K0 09961 05023 0030            TF    Y,BOX,01‡
05023    00005       0040  BOX       DS    5,*‡
05024 J4 09961 000-5 0050            CM    Y,5,010,             TEST FOR CHARACTERISTIC EQUAL 5‡
05036 M7 05216 01200 0060            BNE   *&180,,0‡
05048 K0 05078 05023 0070            TF    BOX2,BOX,01‡
05060 KK 05078 09931 0080            S     BOX2,FF,01,          ADJUST FOR FIELD LENGTH‡
05072 J4 00000 000N0 0090            CM    ,50,010,             TEST FOR PEN DOWN‡
05078    00005       0100  BOX2      DS    5,*-5‡
05084 M7 05120 01200 0110            BNE   *&36,,0‡
05096 L8 09905 00200 0120            WNPT  PENDWN-1,,0‡
05108 42 00000 00000 0130            BB     ‡
05120 K0 05150 05023 0140            TF    BOX3,BOX,01‡
05132 KK 05150 09931 0150            S     BOX3,FF,01,          ADJUST FOR FIELD LENGTH‡
05144 J4 00000 00000 0160            CM    ,60,010,             TEST FOR PEN UP‡
05150    00005       0170  BOX3      DS    5,*-5‡
05156 M7 05192 01200 0180            BNE   *&36,,0,             BRANCH TO INITIATE‡
05168 L8 09908 00200 0190            WNPT  PENUP-1,,0‡
05180 42 00000 00000 0200            BB     ‡
                     0210  *   -IN ITIA  TION-‡
05192 J6 09969 -0000 0220            TFM   CO,0,07,             CLEAR COUNTER TO ZERO‡
05204 M9 05096 00000 0230            B     *-108,,0‡
05216 K0 09923 08917 0240            TF    AX,ZERO1,01,         CLEAR AX TO ZERO‡
05228 K0 09929 08917 0250            TF    AY,ZERO1,01.         CLEAR AY TO ZERO‡
05240 J2 05023 000-2 0260            SM    BOX,2,010‡
05252 K0 05275 05023 0270            TF    BOX1,BOX,01‡
05264 K0 09959 05275 0280            TF    Y-2,BOX1,01,         STORE MANTISA OF THE ARGUMENT‡
05275    00005       0290  BOX1      DS    5,*‡
05276 J4 09969 000-2 0300            CM    CO,2,010,            TEST FOR COUNTER EQUAL 2‡
05288 M6 05312 01200 0310            BE    *&24,,0‡
05300 J1 09969 -0001 0320            AM    CO,1,07‡
05312 2M 00060 09915 0330            C     FAC,EX,1,            TEST FOR X EQUAL ZERO‡
05324 M7 05348 01200 0340            BNE   MISS,,0‡
05336 M9 05468 00000 0360            B     G,,0‡
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I-ADD OP                 P/L LABEL   OP      OPERANDS

                         0370  * -CON VERT  ION OF X AND Y TO FIXED POINT VARIABLES-‡
05348 2M 00060 09911 0380  MISS   C     FAC,EX2,1,           TEST FOR X WITH 2 INTEGERS‡
05360 M6 05672 01100 0390         BP    GABOR,,0‡
05372 M6 05732 01200 0400         BE    FIX2,,0‡
05384 2M 00060 09913 0410         C     FAC,EX0,1,           TEST FOR X WITHOUT INTEGERS‡
05396 M6 05804 01100 0420         BP    FIX1,,0‡
05408 M6 05876 01200 0430         BE    FIX0,,0‡
05420 2M 00060 09917 0440         C     FAC,EXM2,1,          TEST FOR CHARACTERISTIC OF X # -2‡
05432 M6 05948 01100 0450         BP    FIXM1,,0‡
05444 M6 06008 01200 0460         BE    FIXM2,,0‡
05456 K0 09923 08917 0470         TF    AX,ZERO1,01,         SET AX#0 FOR CHARACT. LESS THAN -2‡
05468 KM 09961 09915 0480  G      C     Y,EX,01,             TEST FOR Y EQUAL ZERO‡
05480 M7 05540 01200 0490         BNE   *&60,,0‡
05492 K0 09929 08917 0500         TF    AY,ZERO1,01‡
05504 2M 00060 09915 0510         C     FAC,EX,1,            TEST FOR X EQUAL ZERO‡
05516 M6 06512 01200 0520         BE    FIRST,,0‡
05528 M9 06476 00000 0530         B     F,,0‡
05540 KM 09961 09911 0540         C     Y,EX2,01,            TEST FOR Y WITH 2 INTEGERS‡
05552 M6 06080 01100 0550         BP    FIXY3,,0‡
05564 M6 06140 01200 0560         BE    FIXY2,,0‡
05576 KM 09961 09913 0570         C     Y,EX0,01,            TEST FOR Y WITHOUT INTEGERS‡
05588 M6 06212 01100 0580         BP    FIXY1,,0‡
05600 M6 06284 01200 0590         BE    FIXY0,,0‡
05612 KM 09961 09917 0600         C     Y,EXM2,01,           TEST FOR CHARACTERISTIC OF Y # -2‡
05624 M6 06356 01100 0610         BP    FIXYM1,,0‡
05636 M6 06416 01200 0620         BE    FIXYM2,,0‡
05648 K0 09929 08917 0630         TF    AY,ZERO1,01,         SET AY#0 FOR CHARACT. LESS THAN -2‡
05660 M9 06476 00000 0640         B     F,,0‡
                         0650  * -SEC TION   CORRESPONDING TO VALUES OF X WITH 3 INTEGERS-‡
05672 J6 05719 -0060 0660  GABOR  TFM   BOX4,FAC,07‡
05684 KK 05719 09931 0670         S     BOX4,FF,01,          ADJUST FOR FIELD LENGTH‡
05696 J1 05719 000-4 0680         AM    BOX4,4,010‡
05708 K6 09923 00000 0690         TF    AX,,0‡
05719       00005        0700  BOX4   DS    5,*‡
05720 M9 05468 00000 0710         B     G,,0‡
                         0720  * -SEC TION   CORRESPONDING TO VALUES OF X WITH 2 INTEGERS-‡
05732 J6 05779 -0060 0730  FIX2   TFM   BOX5,FAC,07‡
05744 KK 05779 09931 0740         S     BOX5,FF,01,          ADJUST FOR FIELD LENGTH‡
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I-ADD OP                  P/L LABEL   OP       OPERANDS

05756 J1 05779 000-3 0750             AM     BOX5,3,010‡
05768 K6 09923 00000 0760             TF     AX,,0‡
05779    00005       0770 BOX5        DS     5,*‡
05780 L3 09919 00000 0780             CF     AX-4,,0‡
05792 M9 05468 00000 0790             B      G,,0‡
                     0800 * -SEC      TION    CORRESPONDING TO VALUES OF X WITH 1 INTEGER-‡
05804 J6 05851 -0060 0810 FIX1        TFM    BOX6,FAC,07‡
05816 KK 05851 09931 0820             S      BOX6,FF,01,        ADJUST FOR FIELD LENGTH‡
05828 J1 05851 000-2 0830             AM     BOX6,2,010‡
05840 K6 09923 00000 0840             TF     AX,,0‡
05851    00005       0850 BOX6        DS     5,*‡
05852 L3 09920 00000 0860             CF     AX-3,,0‡
05864 M9 05468 00000 0870             B      G,,0‡
                     0880 * -SEC      TION    CORRESPONDING TO VALUES OF X WITHOUT INTEGERS-‡
05876 J6 05923 -0060 0890 FIX0        TFM    BOX7,FAC,07‡
05888 KK 05923 09931 0900             S      BOX7,FF,01,        ADJUST FOR FIELD LENGTH‡
05900 J1 05923 000-1 0910             AM     BOX7,1,010‡
05912 K6 09923 00000 0920             TF     AX,,0‡
05923    00005       0930 BOX7        DS     5,*‡
05924 L3 09921 00000 0940             CF     AX-2,,0‡
05936 M9 05468 00000 0950             B      G,,0‡
                     0960 * -SEC      TION    FOR CHARACTERISTIC OF X *-1 -‡
05948 J6 05983 -0060 0970 FIXM1       TFM    BOX8,FAC,07‡
05960 KK 05983 09931 0980             S      BOX8,FF,01,        ADJUST FOR FIELD LENGTH‡
05972 K6 09923 00000 0990             TF     AX,,0‡
05983    00005       1000 BOX8        DS     5,*‡
05984 L3 09922 00000 1010             CF     AX-1,,0‡
05996 M9 05468 00000 1020             B      G,,0‡
                     1030 * -SEC      TION    FOR CHARACTERISTIC OF X *-2 -‡
06008 J6 06055 -0060 1040 FIXM2       TFM    BOX9,FAC,07‡
06020 KK 06055 09931 1050             S      BOX9,FF,01,        ADJUST FOR FIELD LENGTH‡
06032 J2 06055 000-1 1060             SM     BOX9,1,010‡
06044 K5 09923 00000 1070             TD     AX,,0‡
06055    00005       1080 BOX9        DS     5,*‡
06056 L3 09923 00000 1090             CF     AX,,0‡
06068 M9 05468 00000 1100             B      G,,0‡
                     1110 * -SEC      TION    FOR VALUES OF Y WITH 3 INTEGERS-‡
06080 J0 06127 -9961 1120 FIXY3       TFM    BOX10,Y,017‡
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I-ADD OP                 P/L LABEL   OP      OPERANDS

06092 KK 06127 09931 1130            S     BOX10,FF,01,          ADJUST FOR FIELD LENGTH‡
06104 J1 06127 000-4 1140            AM    BOX10,4,010‡
06116 K0 09929 00000 1150            TF    AY,,01‡
06127    00005       1160  BOX10     DS    5,*‡
06128 M9 06476 00000 1170            B     F,,0‡
                     1180  * -SEC    TION   FOR VALUES OF Y WITH 2 INTEGERS-‡
06140 J0 06187 -9961 1190  FIXY2     TFM   BOX11,Y,017‡
06152 KK 06187 09931 1200            S     BOX11,FF,01,          ADJUST FOR FIELD LENGTH‡
06164 J1 06187 000-3 1210            AM    BOX11,3,010‡
06176 K0 09929 00000 1220            TF    AY,,01‡
06187    00005       1230  BOX11     DS    5,*‡
06188 L3 09925 00000 1240            CF    AY-4,,0‡
06200 M9 06476 00000 1250            B     F,,0‡
                     1260  * -SEC    TION   FOR VALUES OF Y WITH 1 INTEGER-‡
06212 J0 06259 -9961 1270  FIXY1     TFM   BOX12,Y,017‡
06224 KK 06259 09931 1280            S     BOX12,FF,01,          ADJUST FOR FIELD LENGTH‡
06236 J1 06259 000-2 1290            AM    BOX12,2,010‡
06248 K0 09929 00000 1300            TF    AY,,01‡
06259    00005       1310  BOX12     DS    5,*‡
06260 L3 09926 00000 1320            CF    AY-3,,0‡
06272 M9 06476 00000 1330            B     F,,0‡
                     1340  * -SEC    TION   FOR VALUES OF Y WITHOUT INTEGERS-‡
06284 J0 06331 -9961 1350  FIXY0     TFM   BOX13,Y,017‡
06296 KK 06331 09931 1360            S     BOX13,FF,01,          ADJUST FOR FIELD LENGTH‡
06308 J1 06331 000-1 1370            AM    BOX13,1,010‡
06320 K0 09929 00000 1380            TF    AY,,01‡
06331    00005       1390  BOX13     DS    5,*‡
06332 L3 09927 00000 1400            CF    AY-2,,0‡
06344 M9 06476 00000 1410            B     F,,0‡
                     1420  * -SEC    TION   FOR CHARACTERISTIC OF Y #-1 -‡
06356 J0 06391 -9961 1430  FIXYM1    TFM   BOX14,Y,017‡
06368 KK 06391 09931 1440            S     BOX14,FF,01,          ADJUST FOR FIELD LENGTH‡
06380 K0 09929 00000 1450            TF    AY,,01‡
06391    00005       1460  BOX14     DS    5,*‡
06392 L3 09928 00000 1470            CF    AY-1,,0‡
06404 M9 06476 00000 1480            B     F,,0‡
                     1490  * -SEC    TION   FOR CHARACTERISTIC OF Y #-2‡
06416 J0 06463 -9961 1500  FIXYM2    TFM   BOX15,Y,017‡
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1.0.0-2

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1-ADD OP                P/L LABEL   OP       OPERANDS

06428 KK 06463 09931 1510           S        BOX15,FF,01,        ADJUST FOR FIELD LENGTH‡
06440 J2 06463 000-1 1520           SM       BOX15,1,010‡
06452 KN 09929 00000 1530           TD       AY,,01‡
06463    00005       1540  BOX15    DS       5,*‡
06464 L3 09929 00000 1550           CF       AY,,0‡
06476 P1 09923 00058 1560  F        MF       AX,FAC-2,0,         TEST FOR NEGATIVE X‡
06488 MM 06512 09959 1570           BNF      FIRST,Y-2,01,       TEST FOR NEGATIVE Y‡
06500 L2 09929 00000 1580           SF       AY,,0‡
06512 J4 09969 -0001 1590  FIRST    CM       CO,1,07,            TEST FOR COUNTER EQUAL 1‡
06524 M6 06572 01100 1600           BP       ALL,,0‡
06536 K0 08949 09923 1610           TF       X0,AX,01,           INITIAL VALUE X0‡
06548 K0 08955 09929 1620           TF       Y0,AY,01,           INITIAL VALUE Y0‡
06560 42 00000 00000 1630           BB        ‡
06572 K0 08961 09923 1640  ALL      TF       X1,AX,01‡
06584 K0 08967 09929 1650           TF       Y1,AY,01‡
06596 K0 09885 08961 1660  NEXT1    TF       DELTAX,X1,01‡
06608 KK 09885 08949 1670           S        DELTAX,X0,01,       TOTAL INCREMENT IN THE X DIRECTION‡
06620 K0 09897 09885 1680           TF       ABSDX,DELTAX,01‡
06632 L3 09897 00000 1690           CF       ABSDX,,0‡
06644 K0 09891 08967 1700           TF       DELTAY,Y1,01‡
06656 KK 09891 08955 1710           S        DELTAY,Y0,01,       TOTAL INCREMENT IN THE Y DIRECTION‡
06668 K0 09903 09891 1720           TF       ABSDY,DELTAY,01‡
06680 L3 09903 00000 1730           CF       ABSDY,,0‡
06692 KM 09897 09964 1740           C        ABSDX,TOLER,01,     TEST FOR ABSDX LESS THAN .005‡
06704 M6 06728 01100 1750           BP       *&24,,0‡
06716 M9 08432 00000 1760           B        NEXT5,,0‡
06728 KM 09885 08917 1770           C        DELTAX,ZERO1,01,    TEST FOR DELTAX # 0‡
06740 M6 06932 01100 1780           BP       NEXT2,,0‡
06752 KM 09903 09964 1790           C        ABSDY,TOLER,01,     TEST FOR ABSDY LESS THAN .005‡
06764 M6 06788 01100 1800           BP       *&24,,0‡
06776 M9 08684 00000 1810           B        NEXT6,,0‡
06788 KM 09891 08917 1820           C        DELTAY,ZERO1,01,    TEST FOR DELTAY # 0‡
06800 M6 06872 01100 1830           BP       NEXT3,,0‡
                     1840  * -NEG ATIV E DELTAX AND DELTAY-‡
06812 J0 07238 -9764 1850           TFM      XOUT,SEVSO-1,017‡
06824 J0 07610 -9536 1860           TFM      YOUT,FIVEO-1,017‡
06836 J0 07466 -9650 1870           TFM      XYOUT,SIXSO-1,017‡
06848 J0 07838 -9650 1880           TFM      GOXY2&6,SIXSO-1,017‡
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I-ADD OP                 P/L LABEL   OP      OPERANDS

06860 M9 07100 00000 1890            B       GOGO,,0‡
                     1900 * -NEG ATIV        E DELTAX AND POSITIVE DELTA Y-‡
06872 J0 07238 -9764 1910 NEXT3      TFM     XOUT,SEVSO-1,017‡
06884 J0 07610 -9080 1920            TFM     YOUT,ONESO-1,017‡
06896 J0 07466 -9878 1930            TFM     XYOUT,EIGHO-1,017‡
06908 J0 07838 -9878 1940            TFM     GOXY2&6,EIGHO-1,017‡
06920 M9 07100 00000 1950            B       GOGO,,0‡
                     1960 * -POS ITIV        E DELTAX-‡
06932 KM 09903 09964 1970 NEXT2      C       ABSDY,TOLER,01,     TEST FOR ABSDY LESS THAN .005‡
06944 M6 06966 01100 1980            BP      *&24,,0‡
06956 M9 08684 00000 1990            B       NEXT6,,0‡
06968 KM 09891 08917 2000            C       DELTAY,ZERO1,01,    TEST FOR DELTAY # 0‡
06980 M6 07052 01100 2010            BP      NEXT4,,0‡
                     2020 * -POS ITIV        E DELTAX AND NEGATIVE DELTAY-‡
06992 J0 07238 -9308 2030            TFM     XOUT,THREO-1,017‡
07004 J0 07610 -9536 2040            TFM     YOUT,FIVEO-1,017‡
07016 J0 07466 -9422 2050            TFM     XYOUT,FOURO-1,017‡
07028 J0 07838 -9422 2060            TFM     GOXY2&6,FOURO-1,017‡
07040 M9 07100 00000 2070            B       GOGO,,0‡
                     2080 * -POS ITIV        E DELTAX AND DELTAY-‡
07052 J0 07238 -9308 2090 NEXT4      TFM     XOUT,THREO-1,017‡
07064 J0 07610 -9080 2100            TFM     YOUT,ONESO-1,017‡
07076 J0 07466 -9194 2110            TFM     XYOUT,TWOSO-1,017‡
07088 J0 07838 -9194 2120            TFM     GOXY2&6,TWOSO-1,017‡
07100 KM 09897 09903 2180 GOGO       C       ABSDX,ABSDY,01,     TEST FOR BIGGER INCREMENT‡
07112 M6 07880 01200 2190            BE      OK,,0‡
07124 M7 07508 01300 2200            BN      YBIGER,,0‡
                     2210 * -DEL TAX         GREATER THAN DELTAY-‡
07136 2Q 00096 09903 2220            LD      96,ABSDY,1‡
07148 2R 00097 09897 2230            D       97,ABSDX,1‡
07160 32 00091 00000 2240            SF      91‡
07172 K6 08943 00093 2250            TF      RATIO,93,0,         RATIO DELTAY/DELTAX‡
07184 M9 07880 00000 2260            B       OK,,0‡
                     2270 * -DEL TAX         GREATER THAN DELTAY-‡
07196 KC 08923 09884 2280            TF      XCNTR,DELTAX-1,01,  SET XCOUNTER EQUAL TO DELTAX‡
07208 KJ 08935 08943 2290 GO2        A       XYCNTR,RATIO,01,    MODIFY XYCOUNTER ADDING RATIO‡
07220 ML 07460 08932 2300            BD      GOXY1,XYCNTR-3,01,  TEST FOR DIGIT IN XYCOUNTER‡
07232 38 00000 00200 2310            WNPT     ‡
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I-ADD OP                  P/L LABEL   OP      OPERANDS

07238    00005            2320 XOUT   DS      5,*-5‡
07244 J2 08923 000-1      2330 G03    SM      XCNTR,1,010‡
07256 J4 08923 -0000      2340        CM      XCNTR,0,07,         TEST FOR LAST MOVE‡
07268 M6 07208 01100      2350        BP      G02,,0‡
                          2360 * -FIN AL A    DJUSTMENT IN THE Y DIRECTION-‡
07280 MM 07376 09891      2370        BNF     *&96,DELTAY,01,     TEST FOR NEGATIVE DELTAY‡
                          2380 * -NEG ATIV    E DELTAY-‡
07292 KM 09890 08928      2390        C       DELTAY-1,YCNTR-1,01,TEST FOR FINAL ADJUSTMENT‡
07304 M6 08048 01200      2400        BE      CLEAR,,0‡
07316 M7 07352 01300      2410        BN      *&36,,0‡
07328 L8 09536 00200      2420        WNPT    FIVEO-1,,0‡
07340 M9 08048 00000      2430        B       CLEAR,,0‡
07352 L8 09080 00200      2440        WNPT    ONESO-1,,0‡
07364 M9 08048 00000      2450        B       CLEAR,,0‡
                          2460 * -POS ITIV    E DELTAY-‡
07376 KM 09890 08928      2470        C       DELTAY-1,YCNTR-1,01,TEST FOR FINAL ADJUSTMENT‡
07388 M6 08048 01200      2480        BE      CLEAR,,0‡
07400 M7 07436 01300      2490        BN      *&36,,0‡
07412 L8 09080 00200      2500        WNPT    ONESO-1,,0‡
07424 M9 08048 00000      2510        B       CLEAR,,0‡
07436 L8 09536 00200      2520        WNPT    FIVEO-1,,0‡
07448 M9 08048 01200      2530        B       CLEAR,,0‡
                          2540 * -DIG IT I    N XYCOUNTER %DELTAX GRATER THAN DELTAY¤-‡
07460 38 00000 00200      2550 GOXY1  WNPT     ‡
07466    00005            2560 XYOUT  DS      5,*-5‡
07472 J2 08935 0J000      2570        SM      XYCNTR,1000,08‡
07484 J1 08929 000J0      2580        AM      YCNTR,10,010‡
07496 M9 07244 00000      2590        B       G03,,0‡
                          2600 * -DEL TAY     LARGER THAN DELTAX-‡
07508 2Q 00096 09897      2610 YBIGER LD      96,ABSDX,1‡
07520 2R 00097 09903      2620        D       97,ABSDY,1‡
07532 32 00091 00000      2630        SF      91‡
07544 K6 08943 00093      2640        TF      RATIO,93,0‡
07556 M9 07880 00000      2650        B       OK,,0‡
                          2660 * DELT AY L    ARGER THAN DELTAX‡
07568 K0 08929 09890      2670        TF      YCNTR,DELTAY-1,01,  SET YCOUNTER EQUAL TO DELTAY‡
07580 KJ 08935 08943      2680 G04    A       XYCNTR,RATIO,01,    MODIFY XYCOUNTER ADDING RATIO‡
07592 ML 07832 08932      2690        BD      GOXY2,XYCNTR-3,01,  TEST FOR DIGIT IN XYCOUNTER‡
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I-ADD OP                 P/L LABEL   OP       OPERANDS

07604 38 00000 00200 2700             WNPT    ‡
07610    00005       2710  YOUT       DS      5,*-5‡
07616 J2 08929 000-1 2720  GO5        SM      YCNTR,1,010‡
07628 J4 08929 -0000 2730             CM      YCNTR,0,07,          TEST FOR LAST MOVE‡
07640 M6 07580 01100 2740             BP      GO4,,0‡
                     2750  * -FIN AL A        DJUSTMENT IN THE X DIRECTION-‡
07652 MM 07748 09885 2760             BNF     *&96,DELTAX,01,      TEST FOR NEGATIVE DELTAX‡
                     2770  * -NEG ATIV        E DELTAX-‡
07664 KM 09884 08922 2780             C       DELTAX-1,XCNTR-1,01,TEST FOR FINAL ADJUSTMENT‡
07676 M6 08048 01200 2790             BE      CLEAR,,0‡
07688 M7 07724 01300 2800             BN      *&36,,0‡
07700 L8 09764 00200 2810             WNPT    SEVSO-1,,0‡
07712 M9 08048 00000 2820             B       CLEAR,,0‡
07724 L8 09308 00200 2830             WNPT    THREO-1,,0‡
07736 M9 08048 00000 2840             B       CLEAR,,0‡
                     2850  * -POS ITIV        E DELTAX-‡
07748 KM 09884 08922 2860             C       DELTAX-1,XCNTR-1,01,TEST FOR FINAL ADJUSTMENT‡
07760 M6 08048 01200 2870             BE      CLEAR,,0‡
07772 M7 07808 01300 2880             BN      *&36,,0‡
07784 L8 09308 00200 2890             WNPT    THREO-1,,0‡
07796 M9 08048 00000 2900             B       CLEAR,,0‡
07808 L8 09764 00200 2910             WNPT    SEVSO-1,,0‡
07820 M9 08048 01200 2920             B       CLEAR,,0‡
                     2930  * -DIG IT I        N XYCOUNTER %DELTAY LARGER THAN DELTAX□-‡
07832 38 00000 00200 2940  GOXY2      WNPT    ‡
07844 J2 08935 -1000 2950             SM      XYCNTR,1000,07‡
07856 J1 08923 000J0 2960             AM      XCNTR,10,010‡
07868 M9 07616 00000 2970             B       GO5,,0‡
                     2980  * -DEL TAX         EQUAL TO DELTAY-‡
07880 PJ 09832 09885 2990  OK         MF      DELTAX-3,DELTAX,01‡
07892 J1 09885 000-5 3000             AM      DELTAX,5,010,        ROUND OFF DELTAX‡
07904 J5 09885 00000 3010             TDM     DELTAX,0,0‡
07916 PJ 09885 09882 3020             MF      DELTAX,DELTAX-3,01‡
07928 KJ 08949 09885 3030             A       X0,DELTAX,01,        ADJUST X0‡
07940 PJ 09888 09891 3040             MF      DELTAY-3,DELTAY,01‡
07952 J1 09891 000-5 3050             AM      DELTAY,5,010,        ROUND OFF DELTAY‡
07964 J5 09891 00000 3060             TDM     DELTAY,0,0‡
07976 PJ 09891 09888 3070             MF      DELTAY,DELTAY-3,01‡
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I-ADD OP                P/L LABEL   OP     OPERANDS

07988 KJ 08955 09891 3080          A      Y0,DELTAY,01,      ADJUST Y0‡
08000 KM 09884 09890 3090          C      DELTAX-1,DELTAY-1,01,TEST FOR LARGER INCREMENT‡
08012 M7 07568 01300 3100          BN     G04-12,,0‡
08024 M6 08096 01200 3110          BE     XYGO,,0‡
08036 M9 07196 00000 3120          B      G02-12,,0‡
                     3130 * -CLE   AR X   COUNTER AND YCOUNTER TO ZEROS AND SET XYCOUNTER #.005 -‡
08048 J6 08935 -0005 3140 CLEAR    TFM    XYCNTR,5,07‡
08060 K0 08923 08917 3150          TF     XCNTR,ZERO1,01‡
08072 K0 08929 08917 3160          TF     YCNTR,ZERO1,01‡
08084 42 00000 00000 3170          BB      ‡
                     3180 * DELT   AX E   QUAL TO DELTAY‡
08096 K0 08246 07466 3190 XYGO     TF     FILL1,XYOUT,01‡
08108 J2 07466 000J1 3200          SM     XYOUT,11,010‡
08120 K0 08306 07466 3210          TF     FILL2,XYOUT,01‡
08132 J2 07466 00J01 3220          SM     XYOUT,101,09‡
08144 K0 08366 07466 3230          TF     FILL3,XYOUT,01‡
08156 K0 08414 07466 3240          TF     FILL4,XYOUT,01‡
08168 K0 08922 09884 3250          TF     XCNTR-1,DELTAX-1,01,SET XCOUNTER EQUAL TO DELTAX‡
08180 ML 08396 08919 3260 FAST     BD     TENS,XCNTR-4,01,   TEST FOR DIGIT IN THE TENS POSITION‡
08192 ML 08336 08920 3270          BD     UNITS,XCNTR-3,01,  TEST FOR DIGIT IN THE UNITS POSIT.‡
08204 ML 08276 08921 3280          BD     TENTHS,XCNTR-2,01, TEST FOR DIGIT IN THE 1/10 POSIT.‡
08216 J4 08922 -0000 3290 LAST     CM     XCNTR-1,0,07,      TEST FOR LAST SINGLE MOVE‡
08228 M7 08048 01100 3300          BNP    CLEAR,,0‡
08240 38 00000 00200 3310          WNPT    ‡
08246    00005       3320 FILL1    DS     5,*-5‡
08252 J2 08922 000-1 3330          SM     XCNTR-1,1,010‡
08264 M9 08216 00000 3340          B      LAST,,0‡
08276 J4 08921 0-000 3350 TENTHS   CM     XCNTR-2,0,08,      TEST FOR LAST 1/10 INCH MOVE‡
08288 M7 08216 01100 3360          BNP    LAST,,0‡
08300 38 00000 00200 3370          WNPT    ‡
08306    00005       3380 FILL2    DS     5,*-5‡
08312 J2 08921 000-1 3390          SM     XCNTR-2,1,010‡
08324 M9 08276 00000 3400          B      TENTHS,,0‡
08336 J4 08920 00-00 3410 UNITS    CM     XCNTR-3,0,09,      TEST FOR LAST ONE INCH MOVE‡
08348 M7 08276 01100 3420          BNP    TENTHS,,0‡
08360 38 00000 00200 3430          WNPT    ‡
08366    00005       3440 FILL3    DS     5,*-5‡
08372 J2 08920 000-1 3450          SM     XCNTR-3,1,010‡
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I-ADD OP                P/L LABEL    OP      OPERANDS

08384 M9 08336 00000 3460            B       UNITS,,0‡
08396 J2 08920 000-1 3470  TENS      SM      XCNTR-3,1,010‡
08408 38 00000 00200 3480            WNPT     ‡
08414    00005       3490  FILL4     DS      5,*-5‡
08420 M9 08180 00000 3500            B       FAST,,0‡
                     3510  * -DEL    TAX     EQUAL ZERO-‡
08432 KM 09903 09964 3520  NEXT5     C       ABSDY,TOLER,01,    TEST FOR ABSDY LESS THAN .005‡
08444 M6 08468 01100 3530            BP      *&24,,0‡
08456 M9 08048 00000 3540            B       CLEAR,,0‡
08468 KM 09891 08917 3550            C       DELTAY,ZERO1,01,   TEST FOR DELTAY EQUAL ZERO‡
08480 M6 08576 01100 3560            BP      NEXT55,,0‡
                     3570  * -DEL    TAX     EQUAL ZERO AND NEGATIVE DELTAY-‡
08492 J0 08246 -9536 3580            TFM     FILL1,FIVEO-1,017‡
08504 J0 08306 -9525 3590            TFM     FILL2,FIVET-10,017‡
08516 J0 08366 -9424 3600            TFM     FILL3,FIVEH-49,017‡
08528 J0 08414 -9424 3610            TFM     FILL4,FIVEH-49,017‡
08540 J2 09891 000-5 3620            SM      DELTAY,5,010,      ROUND OFF DELTAY‡
08552 J5 09891 0000- 3630            TDM     DELTAY,,011‡
08564 M9 08648 00000 3640            B       NEXTY,,0‡
                     3650  * -DEL    TAX     EQUAL ZERO AND POSITIVE DELTAY-‡
08576 J0 08246 -9080 3660  NEXT55    TFM     FILL1,ONESO-1,017‡
08588 J0 08306 -9069 3670            TFM     FILL2,ONEST-10,017‡
08600 J0 08366 -8968 3680            TFM     FILL3,ONESH-49,017‡
08612 K0 08414 08366 3690            TF      FILL4,FILL3,01‡
08624 J1 09891 000-5 3700            AM      DELTAY,5,010,      ROUND OFF DELTAY‡
08636 J5 09891 00000 3710            TDM     DELTAY,0,0‡
08648 K0 08922 09890 3720  NEXTY     TF      XCNTR -1,DELTAY-1,01,SET XCOUNTER EQUAL TO DELTAY‡
08660 KJ 08955 09891 3730            A       YO,DELTAY,01,      ADJUST YO‡
08672 M9 08180 00000 3740            B       FAST,,0‡
                     3750  * -DEL    TAY     EQUAL ZERO-‡
08684 MM 08804 09885 3760  NEXT6     BNF     NEXT66,DELTAX,01,  TEST FOR NEGATIVE DELTAX‡
                     3770  * -DEL    TAY     EQUAL ZERO AND NEGATIVE DELTAX-‡
08696 J2 09885 000-5 3780            SM      DELTAX,5,010,      ROUND OFF DELTAX‡
08708 J5 09885 0000- 3790            TDM     DELTAX,0,011‡
08720 J0 08246 -9764 3800            TFM     FILL1,SEVSO-1,017‡
08732 J0 08306 -9753 3810            TFM     FILL2,SEVST-10,017‡
08744 J0 08366 -9652 3820            TFM     FILL3,SEVSH-49,017‡
08756 K0 08414 08366 3830            TF      FILL4,FILL3,01‡
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 1-ADD OP                  P/L LABEL   OP      OPERANDS

08768 K0 08922 09884 3840            TF      XCNTR-1,DELTAX-1,01,SET XCOUNTER EQUAL TO DELTAX‡
08780 KJ 08949 09885 3850            A       X0,DELTAX,01,      ADJUST X0‡
08792 M9 08180 00000 3860            B       FAST,,0‡
                     3870  * -DEL    TAY     EQUAL ZERO AND POSITIVE DELTAX-‡
08804 J0 08246 -9308 3880  NEXT66    TFM     FILL1,THREO-1,017‡
08816 J0 08306 -9297 3890            TFM     FILL2,THRET-10,017‡
08828 J0 08366 -9196 3900            TFM     FILL3,THREH-49,017‡
08840 K0 08414 08366 3910            TF      FILL4,FILL3,01‡
08852 J1 09885 000-5 3920            AM      DELTAX,5,010,      ROUND OFF DELTAX‡
08864 J5 09885 00000 3930            TDM     DELTAX,0,0‡
08876 K0 08922 09884 3940            TF      XCNTR-1,DELTAX-1,01,SET XCOUNTER EQUAL TO DELTAX‡
08888 KJ 08949 09885 3950            A       X0,DELTAX,01,      ADJUST X0‡
08900 M9 08180 00000 3960            B       FAST,,0‡
08917    00006       3970  ZERO1     DC      6,0‡
39700-00000‡                                                    -6-8912-8918-
08923    00006       3980  XCNTR     DC      6,0‡
39800-00000‡                                                    -6-8918-8924-
08929    00006       3990  YCNTR     DC      6,0‡
39900-00000‡                                                    -6-8924-8930-
08935    00006       4000  XYCNTR    DC      6,5‡
40000-00005‡                                                    -6-8930-8936-
08943    00008       4010  RATIO     DS      8‡
08949    00006       4020  X0        DS      6,,,               X VALUE OF THE PEN AFTER EACH MOVE‡
08955    00006       4030  Y0        DS      6,,,               Y VALUE OF THE PEN AFTER EACH MOVE‡
08961    00006       4040  X1        DS      6,,,               COORDINATE X OF THE NEW POINT‡
08967    00006       4050  Y1        DS      6,,,               COORDINATE Y OF THE NEW POINT‡
09017    00050       4060  ONESH     DC      50,11111111111111111111111111111111111111111111111‡
40600J111111111111111111111111111111111111111111111111‡         -6-8968-9018-
09067    00050       4070            DC      50,11111111111111111111111111111111111111111111111‡
40700J111111111111111111111111111111111111111111111111‡         -6-9018-9068-
09068    00001       4080            DC      1,@‡
40800‡                                                          -6-9068-9069-
09079    00011       4090  ONEST     DC      11,1111111111@‡
40900J1111111111‡                                               -6-9069-9080-
09081    00002       4100  ONESO     DC      2,1@‡
41000J‡                                                         -6-9080-9082-
09131    00050       4110  TWOSH     DC      50,22222222222222222222222222222222222222222222222‡
41100K222222222222222222222222222222222222222222222222‡         -6-9082-9132-
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I-ADD OP              P/L LABEL   OP      OPERANDS

09181    00050        4120        DC      50,22222222222222222222222222222222222222222222222222*
41200K2222222222222222222222222222222222222222222222222*       -6-9132-9182-
09182    00001        4130        DC      1,@*
41300*                                                          -6-9182-9183-
09193    00011        4140  TWOST DC      11,2222222222@*
41400K222222222*                                                -6-9183-9194-
09195    00002        4150  TWOSO DC      2,2@*
41500K*                                                         -6-9194-9196-
09245    00050        4160  THREH DC      50,33333333333333333333333333333333333333333333333333*
41600L3333333333333333333333333333333333333333333333333*       -6-9196-9246-
09295    00050        4170        DC      50,33333333333333333333333333333333333333333333333333*
41700L3333333333333333333333333333333333333333333333333*       -6-9246-9296-
09296    00001        4180        DC      1,@*
41800*                                                          -6-9296-9297-
09307    00011        4190  THRET DC      11,3333333333@*
41900L333333333*                                                -6-9297-9308-
09309    00002        4200  THREO DC      2,3@*
42000L*                                                         -6-9308-9310-
09359    00050        4210  FOURH DC      50,44444444444444444444444444444444444444444444444444*
42100M4444444444444444444444444444444444444444444444444*       -6-9310-9360-
09409    00050        4220        DC      50,44444444444444444444444444444444444444444444444444*
42200M4444444444444444444444444444444444444444444444444*       -6-9360-9410-
09410    00001        4230        DC      1,@*
42300*                                                          -6-9410-9411-
09421    00011        4240  FOURT DC      11,4444444444@*
42400M444444444*                                                -6-9411-9422-
09423    00002        4250  FOURO DC      2,4@*
42500M*                                                         -6-9422-9424-
09473    00050        4260  FIVEH DC      50,55555555555555555555555555555555555555555555555555*
42600N5555555555555555555555555555555555555555555555555*       -6-9424-9474-
09523    00050        4270        DC      50,55555555555555555555555555555555555555555555555555*
42700N5555555555555555555555555555555555555555555555555*       -6-9474-9524-
09524    00001        4280        DC      1,@*
42800*                                                          -6-9524-9525-
09535    00011        4290  FIVET DC      11,5555555555@*
42900N555555555*                                                -6-9525-9536-
09537    00002        4300  FIVEO DC      2,5@*
43000N*                                                         -6-9536-9538-
```

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1,0,0-2

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I-ADD OP              P/L LABEL   OP      OPERANDS

09587    00050        4310  SIXSH  DC     50,6666666666666666666666666666666666666666666‡
431000666666666666666666666666666666666666666666‡      -6-9538-9588-
09637    00050        4320         DC     50,6666666666666666666666666666666666666666666‡
432000666666666666666666666666666666666666666666‡      -6-9588-9638-
09638    00001        4330         DC     1,@‡
43300‡                                                 -6-9638-9639-
09649    00011        4340  SIXST  DC     11,666666666@‡
43400066666666‡                                        -6-9639-9650-
09651    00002        4350  SIXSO  DC     2,6@‡
435000‡                                                -6-9650-9652-
09701    00050        4360  SEVSH  DC     50,7777777777777777777777777777777777777777777‡
43600P777777777777777777777777777777777777777777‡      -6-9652-9702-
09751    00050        4370         DC     50,7777777777777777777777777777777777777777777‡
43700P777777777777777777777777777777777777777777‡      -6-9702-9752-
09752    00001        4380         DC     1,@‡
43800‡                                                 -6-9752-9753-
09763    00011        4390  SEVST  DC     11,777777777@‡
43900P77777777‡                                        -6-9753-9764-
09765    00002        4400  SEVSO  DC     2,7@‡
44000P‡                                                -6-9764-9766-
09815    00050        4410  EIGHH  DC     50,8888888888888888888888888888888888888888888‡
44100Q888888888888888888888888888888888888888888‡      -6-9766-9816-
09865    00050        4420         DC     50,8888888888888888888888888888888888888888888‡
44200Q888888888888888888888888888888888888888888‡      -6-9816-9866-
09866    00001        4430         DC     1,@‡
44300‡                                                 -6-9866-9867-
09877    00011        4440  EIGHT  DC     11,888888888@‡
44400Q88888888‡                                        -6-9867-9878-
09879    00002        4450  EIGHO  DC     2,8@‡
44500Q‡                                                -6-9878-9880-
09885    00006        4460  DELTAX DS     6,,,              INCREMENT IN THE X DIRECTION‡
09891    00006        4470  DELTAY DS     6,,,              INCREMENT IN THE Y DIRECTION‡
09897    00006        4480  ABSDX  DS     6,,,              ABSOLUTE VALUE OF DELTAX‡
09903    00006        4490  ABSDY  DS     6,,,              ABSOLUTE VALUE OF DELTAY‡
09906    00003        4510  PENDWN DC     3,0@‡
45100-0‡                                               -6-9904-9907-
09909    00003        4520  PENUP  DC     3,9@‡
45200-9‡                                               -6-9907-9910-
```

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I-ADD OP                  P/L LABEL   OP       OPERANDS

09911     00002          4530  EX2    DC    2,2*
45300-2*                                                            -6-9910-9912-
09913     00002          4540  EX0    DC    2,0*
45400-0*                                                            -6-9912-9914-
09915     00002          4550  EX     DC    2,-9-9*
45500RR*                                                            -6-9914-9916-
09917     00002          4560  EXM2   DC    2,-2*
45600-K*                                                            -6-9916-9918-
09923     00006          4570  AX     DS    6,,,                 INITIAL ADRESS OF X*
09929     00006          4580  AY     DS    6,,,                 INITIAL ADRESS OF Y*
00060     00003          4590  FAC    DS    3,60,,               FLOATING POINT ACCUMULATOR*
59829     00004          4600  ARG    DS    4,59829,,               ARGUMENT*
09931     00002          4610  FF     DC    2,8,,                FLOATING POINT FIELD LENGTH*
46100-8*                                                            -6-9930-9932-
09961     00030          4620  Y      DC    30,0*
46200-000000000000000000000000000000*                               -6-9932-9962-
09964     00003          4630  TOLER  DC    3,5,,                TOLERENCE OF .005 INCH*
46300-05*                                                           -6-9962-9965-
09969     00005          4640  CO     DC    5,0*
46400-0000*                                                         -6-9965-9970-
05000                    4650         DEND  5000*
46500  L60000000500490000*                                          -8-0096-0115-
360010000500360017200500360024400500360031600500360000000500            -
00000000000102030400020406080003060902100408021610050015102006021814200* -
7041128200806142230090817263000000000005060708090012141618151811242720242* -
822363520353045403632484455324946536048465462754453627180123456789123456* -
789-23456789-J3456789-JK456789-JKL56789-JKLM6789-JKLMN789-JKLMN089-JKLMN* -
M800000000049-50000P9-JKLMNUPQ*    L1003880001 9M9000000000M9000360000 0  -
```

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I-ADD OP                  P/L LABEL   OP      OPERANDS

360007200500360020100500440001200275260005900274250001100000260009000269  -
26000950026431000000020026001140027425000000001149000120000 0             -
                          0001  *     PL OT S  UBROUTINE - FORTRAN II  12/14/62‡
10000                     0010        DORG    10000‡
10000 KO 10023 09999 0020             TF      BOX,ARG,01,          STORE ADRESS OF THE ARGUMENT IN BOX‡
10012 KO 14959 10023 0030             TF      Y,BOX,01‡
10023    00005       0040  BOX        DS      5,*‡
10024 J4 14959 000-5 0050             CM      Y,5,010,             TEST FOR CHARACTERISTIC EQUAL 5‡
10036 M7 10216 01200 0060             BNE     *&180,,0‡
10048 KO 10078 10023 0070             TF      BOX2,BOX,01‡
10060 K2 10078 00402 0080             S       BOX2,FF,0,           ADJUST FOR FIELD LENGTH‡
10072 J4 00000 000N0 0090             CM      ,50,010,             TEST FOR PEN DOWN‡
10078    00005       0100  BOX2       DS      5,*-5‡
10084 M7 10120 01200 0110             BNE     *&36,,0‡
10096 L8 14905 00200 0120             WNPT    PENDWN-1,,0‡
10108 42 00000 00000 0130             BB       ‡
10120 KO 10150 10023 0140             TF      BOX3,BOX,01‡
10132 K2 10150 00402 0150             S       BOX3,FF,0,           ADJUST FOR FIELD LENGTH‡
10144 J4 00000 00000 0160             CM      ,60,010,             TEST FOR PEN UP‡
10150    00005       0170  BOX3       DS      5,*-5‡
10156 M7 10192 01200 0180             BNE     *&36,,0,             BRANCH TO INITIATE‡
10168 L8 14908 00200 0190             WNPT    PENUP-1,,0‡
10180 42 00000 00000 0200             BB       ‡
                          0210  *   -IN ITIA  TION-‡
10192 J6 14967 -0000 0220             TFM     CO,0,07,             CLEAR COUNTER TO ZERO‡
10204 M9 10096 00000 0230             B       *-108,,0‡
10216 KO 14923 13917 0240             TF      AX,ZERO1,01,         CLEAR AX TO ZERO‡
10228 KO 14929 13917 0250             TF      AY,ZERO1,01,         CLEAR AY TO ZERO‡
10240 J2 10023 000-2 0260             SM      BOX,2,010‡
10252 KO 10275 10023 0270             TF      BOX1,BOX,01‡
10264 KO 14957 10275 0280             TF      Y-2,BOX1,01,         STORE MANTISA OF THE ARGUMENT‡
10275    00005       0290  BOX1       DS      5,*‡
10276 J4 14967 000-2 0300             CM      CO,2,010,            TEST FOR COUNTER EQUAL 2‡
10288 M6 10312 01200 0310             BE      *&24,,0‡
10300 J1 14967 -0001 0320             AM      CO,1,07‡
10312 2M 00485 14915 0330             C       FAC,EX,1,            TEST FOR X EQUAL ZERO‡
10324 M7 10348 01200 0340             BNE     MISS,,0‡
10336 M9 10468 00000 0360             B       G,,0‡
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I-ADD OP                P/L LABEL   OP      OPERANDS

                        0370  * -CON VERT  ION OF X AND Y TO FIXED POINT VARIABLES-‡
10348 2M 00485 14911 0380  MISS   C     FAC,EX2,1,         TEST FOR X WITH 2 INTEGERS‡
10360 M6 10672 01100 0390         BP    GABOR,,0‡
10372 M6 10732 01200 0400         BE    FIX2,,0‡
10384 2M 00485 14913 0410         C     FAC,EX0,1,         TEST FOR X WITHOUT INTEGERS‡
10396 M6 10804 01100 0420         BP    FIX1,,0‡
10408 M6 10876 01200 0430         BE    FIX0,,0‡
10420 2M 00485 14917 0440         C     FAC,EXM2,1,        TEST FOR CHARACTERISTIC OF X # -2‡
10432 M6 10948 01100 0450         BP    FIXM1,,0‡
10444 M6 11008 01200 0460         BE    FIXM2,,0‡
10456 K0 14923 13917 0470         TF    AX,ZERO1,01,       SET AX#0 FOR CHARACT. LESS THAN -2‡
10468 KM 14959 14915 0480  G      C     Y,EX,01,           TEST FOR Y EQUAL ZERO‡
10480 M7 10540 01200 0490         BNE   *&60,,0‡
10492 K0 14929 13917 0500         TF    AY,ZERO1,01‡
10504 2M 00485 14915 0510         C     FAC,EX,1,          TEST FOR X EQUAL ZERO‡
10516 M6 11512 01200 0520         BE    FIRST,,0‡
10528 M9 11476 00000 0530         B     F,,0‡
10540 KM 14959 14911 0540         C     Y,EX2,01,          TEST FOR Y WITH 2 INTEGERS‡
10552 M6 11080 01100 0550         BP    FIXY3,,0‡
10564 M6 11140 01200 0560         BE    FIXY2,,0‡
10576 KM 14959 14913 0570         C     Y,EX0,01,          TEST FOR Y WITHOUT INTEGERS‡
10588 M6 11212 01100 0580         BP    FIXY1,,0‡
10600 M6 11284 01200 0590         BE    FIXY0,,0‡
10612 KM 14959 14917 0600         C     Y,EXM2,01,         TEST FOR CHARACTERISTIC OF Y # -2‡
10624 M6 11356 01100 0610         BP    FIXYM1,,0‡
10636 M6 11416 01200 0620         BE    FIXYM2,,0‡
10648 K0 14929 13917 0630         TF    AY,ZERO1,01,       SET AY#0 FOR CHARACT. LESS THAN -2‡
10660 M9 11476 00000 0640         B     F,,0‡
                        0650  * -SEC TION   CORRESPONDING TO VALUES OF X WITH 3 INTEGERS-‡
10672 J6 10719 -0485 0660  GABOR  TFM   BOX4,FAC,07‡
10684 K2 10719 00402 0670         S     BOX4,FF,0‡
10696 J1 10719 000-4 0680         AM    BOX4,4,010‡
10708 K6 14923 00000 0690         TF    AX,,0‡
10719    00005       0700  BOX4   DS    5,*‡
10720 M9 10468 00000 0710         B     G,,0‡
                        0720  * -SEC TION   CORRESPONDING TO VALUES OF X WITH 2 INTEGERS-‡
10732 J6 10779 -0485 0730  FIX2   TFM   BOX5,FAC,07‡
10744 K2 10779 00402 0740         S     BOX5,FF,0‡
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I-ADD OP                      P/L LABEL   OP       OPERANDS

10756 J1 10779 000-3 0750             AM     BOX5,3,010‡
10768 K6 14923 00000 0760             TF     AX,,0‡
10779    00005       0770  BOX5       DS     5,*‡
10780 L3 14919 00000 0780             CF     AX-4,,0‡
10792 M9 10468 00000 0790             B      G,,0‡
                     0800  * -SEC    TION     CORRESPONDING TO VALUES OF X WITH 1 INTEGER-‡
10804 J6 10851 -0485 0810  FIX1       TFM    BOX6,FAC,07‡
10816 K2 10851 00402 0820             S      BOX6,FF,0‡
10828 J1 10851 000-2 0830             AM     BOX6,2,010‡
10840 K6 14923 00000 0840             TF     AX,,0‡
10851    00005       0850  BOX6       DS     5,*‡
10852 L3 14920 00000 0860             CF     AX-3,,0‡
10864 M9 10468 00000 0870             B      G,,0‡
                     0880  * -SEC    TION     CORRESPONDING TO VALUES OF X WITHOUT INTEGERS-‡
10876 J6 10923 -0485 0890  FIX0       TFM    BOX7,FAC,07‡
10888 K2 10923 00402 0900             S      BOX7,FF,0‡
10900 J1 10923 000-1 0910             AM     BOX7,1,010‡
10912 K6 14923 00000 0920             TF     AX,,0‡
10923    00005       0930  BOX7       DS     5,*‡
10924 L3 14921 00000 0940             CF     AX-2,,0‡
10936 M9 10468 00000 0950             B      G,,0‡
                     0960  * -SEC    TION     FOR CHARACTERISTIC OF X #-1 -‡
10948 J6 10983 -0485 0970  FIXM1      TFM    BOX8,FAC,07‡
10960 K2 10983 00402 0980             S      BOX8,FF,0‡
10972 K6 14923 00000 0990             TF     AX,,0‡
10983    00005       1000  BOX8       DS     5,*‡
10984 L3 14922 00000 1010             CF     AX-1,,0‡
10996 M9 10468 00000 1020             B      G,,0‡
                     1030  * -SEC    TION     FOR CHARACTERISTIC OF X #-2 -‡
11008 J6 11055 -0485 1040  FIXM2      TFM    BOX9,FAC,07‡
11020 K2 11055 00402 1050             S      BOX9,FF,0‡
11032 J2 11055 000-1 1060             SM     BOX9,1,010‡
11044 K5 14923 00000 1070             TD     AX,,0‡
11055    00005       1080  BOX9       DS     5,*‡
11056 L3 14923 00000 1090             CF     AX,,0‡
11068 M9 10468 00000 1100             B      G,,0‡
                     1110  * -SEC    TION     FOR VALUES OF Y WITH 3 INTEGERS-‡
11080 J0 11127 J4959 1120  FIXY3      TFM    BOX10,Y,017‡
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I-ADD OP                 P/L LABEL   OP       OPERANDS

11092 K2 11127 00402 1130            S      BOX10,FF,0‡
11104 J1 11127 000-4 1140            AM     BOX10,4,010‡
11116 KO 14929 00000 1150            TF     AY,,01‡
11127    00005       1160 BOX10      DS     5,*‡
11128 M9 11476 00000 1170            B      F,,0‡
                     1180 * -SEC     TION    FOR VALUES OF Y WITH 2 INTEGERS-‡
11140 JO 11187 J4959 1190 FIXY2      TFM    BOX11,Y,017‡
11152 K2 11187 00402 1200            S      BOX11,FF,0‡
11164 J1 11187 000-3 1210            AM     BOX11,3,010‡
11176 KO 14929 00000 1220            TF     AY,,01‡
11187    00005       1230 BOX11      DS     5,*‡
11188 L3 14925 00000 1240            CF     AY-4,,0‡
11200 M9 11476 00000 1250            B      F,,0‡
                     1260 * -SEC     TION    FOR VALUES OF Y WITH 1 INTEGER-‡
11212 JO 11259 J4959 1270 FIXY1      TFM    BOX12,Y,017‡
11224 K2 11259 00402 1280            S      BOX12,FF,0‡
11236 J1 11259 000-2 1290            AM     BOX12,2,010‡
11248 KO 14929 00000 1300            TF     AY,,01‡
11259    00005       1310 BOX12      DS     5,*‡
11260 L3 14926 00000 1320            CF     AY-3,,0‡
11272 M9 11476 00000 1330            B      F,,0‡
                     1340 * -SEC     TION    FOR VALUES OF Y WITHOUT INTEGERS-‡
11284 JO 11331 J4959 1350 FIXY0      TFM    BOX13,Y,017‡
11296 K2 11331 00402 1360            S      BOX13,FF,0‡
11308 J1 11331 000-1 1370            AM     BOX13,1,010‡
11320 KO 14929 00000 1380            TF     AY,,01‡
11331    00005       1390 BOX13      DS     5,*‡
11332 L3 14927 00000 1400            CF     AY-2,,0‡
11344 M9 11476 00000 1410            B      F,,0‡
                     1420 * -SEC     TION    FOR CHARACTERISTIC OF Y #-1 -‡
11356 JO 11391 J4959 1430 FIXYM1     TFM    BOX14,Y,017‡
11368 K2 11391 00402 1440            S      BOX14,FF,0‡
11380 KO 14929 00000 1450            TF     AY,,01‡
11391    00005       1460 BOX14      DS     5,*‡
11392 L3 14928 00000 1470            CF     AY-1,,0‡
11404 M9 11476 00000 1480            B      F,,0‡
                     1490 * -SEC     TION    FOR CHARACTERISTIC OF Y #-2‡
11416 JO 11463 J4959 1500 FIXYM2     TFM    BOX15,Y,017‡
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I-ADD OP                   P/L LABEL   OP       OPERANDS

11428 K2 11463 00402 1510              S      BOX15,FF,0‡
11440 J2 11463 000-1 1520              SM     BOX15,1,010‡
11452 KN 14929 00000 1530              TD     AY,,01‡
11463    00005       1540   BOX15      DS     5,*‡
11464 L3 14929 00000 1550              CF     AY,,0‡
11476 P1 14923 00483 1560   F          MF     AX,FAC-2,0,         TEST FOR NEGATIVE X‡
11488 MM 11512 14957 1570              BNF    FIRST,Y-2,01,       TEST FOR NEGATIVE Y‡
11500 L2 14929 00000 1580              SF     AY,,0‡
11512 J4 14967 -0001 1590   FIRST      CM     CO,1,07,            TEST FOR COUNTER EQUAL 1‡
11524 M6 11572 01100 1600              BP     ALL,,0‡
11536 KO 13949 14923 1610              TF     X0,AX,01,           INITIAL VALUE X0‡
11548 KO 13955 14929 1620              TF     Y0,AY,01,           INITIAL VALUE Y0‡
11560 42 00000 00000 1630              BB      ‡
11572 KO 13961 14923 1640   ALL        TF     X1,AX,01‡
11584 KO 13967 14929 1650              TF     Y1,AY,01‡
11596 KO 14885 13961 1660   NEXT1      TF     DELTAX,X1,01‡
11608 KK 14885 13949 1670              S      DELTAX,X0,01,       TOTAL INCREMENT IN THE X DIRECTION‡
11620 KO 14897 14885 1680              TF     ABSDX,DELTAX,01‡
11632 L3 14897 00000 1690              CF     ABSDX,,0‡
11644 KO 14891 13967 1700              TF     DELTAY,Y1,01‡
11656 KK 14891 13955 1710              S      DELTAY,Y0,01,       TOTAL INCREMENT IN THE Y DIRECTION‡
11668 KO 14903 14891 1720              TF     ABSDY,DELTAY,01‡
11680 L3 14903 00000 1730              CF     ABSDY,,0‡
11692 KM 14897 14962 1740              C      ABSDX,TOLER,01,     TEST FOR ABSDX LESS THAN .005‡
11704 M6 11728 01100 1750              BP     *&24,,0‡
11716 M9 13432 00000 1760              B      NEXT5,,0‡
11728 KM 14885 13917 1770              C      DELTAX,ZERO1,01,    TEST FOR DELTAX # 0‡
11740 M6 11932 01100 1780              BP     NEXT2,,0‡
11752 KM 14903 14962 1790              C      ABSDY,TOLER,01,     TEST FOR ABSDY LESS THAN .005‡
11764 M6 11788 01100 1800              BP     *&24,,0‡
11776 M9 13684 00000 1810              B      NEXT6,,0‡
11788 KM 14891 13917 1820              C      DELTAY,ZERO1,01,    TEST FOR DELTAY # 0‡
11800 M6 11872 01100 1830              BP     NEXT3,,0‡
                     1840   * -NEG     ATIV   E DELTAX AND DELTAY-‡
11812 JO 12238 J4764 1850              TFM    XOUT,SEVSO-1,017‡
11824 JO 12610 J4536 1860              TFM    YOUT,FIVEO-1,017‡
11836 JO 12466 J4650 1870              TFM    XYOUT,SIXSO-1,017‡
11848 JO 12838 J4650 1880              TFM    GOXY2&6,SIXSO-1,017‡
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I-ADD OP                    P/L LABEL   OP       OPERANDS

11860 M9 12100 00000 1890             B      GOGO,,0‡
                     1900  * -NEG ATIV   E DELTAX AND POSITIVE DELTA Y-‡
11872 JO 12238 J4764 1910  NEXT3  TFM    XOUT,SEVSO-1,017‡
11884 JO 12610 J4080 1920         TFM    YOUT,ONESO-1,017‡
11896 JO 12466 J4878 1930         TFM    XYOUT,EIGHO-1,017‡
11908 JO 12838 J4878 1940         TFM    GOXY2&6,EIGHO-1,017‡
11920 M9 12100 00000 1950         B      GOGO,,0‡
                     1960  * -POS ITIV   E DELTAX-‡
11932 KM 14903 14962 1970  NEXT2  C      ABSDY,TOLER,01,    TEST FOR ABSDY LESS THAN .005‡
11944 M6 11968 01100 1980         BP     *&24,,0‡
11956 M9 13684 00000 1990         B      NEXT6,,0‡
11968 KM 14891 13917 2000         C      DELTAY,ZERO1,01,   TEST FOR DELTAY # 0‡
11980 M6 12052 01100 2010         BP     NEXT4,,0‡
                     2020  * -POS ITIV   E DELTAX AND NEGATIVE DELTAY-‡
11992 JO 12238 J4308 2030         TFM    XOUT,THREO-1,017‡
12004 JO 12610 J4536 2040         TFM    YOUT,FIVEO-1,017‡
12016 JO 12466 J4422 2050         TFM    XYOUT,FOURO-1,017‡
12028 JO 12838 J4422 2060         TFM    GOXY2&6,FOURO-1,017‡
12040 M9 12100 00000 2070         B      GOGO,,0‡
                     2080  * -POS ITIV   E DELTAX AND DELTAY-‡
12052 JO 12238 J4308 2090  NEXT4  TFM    XOUT,THREO-1,017‡
12064 JO 12610 J4080 2100         TFM    YOUT,ONESO-1,017‡
12076 JO 12466 J4194 2110         TFM    XYOUT,TWOSO-1,017‡
12088 JO 12838 J4194 2120         TFM    GOXY2&6,TWOSO-1,017‡
12100 KM 14897 14903 2180  GOGO   C      ABSDX,ABSDY,01,    TEST FOR BIGGER INCREMENT‡
12112 M6 12880 01200 2190         BE     OK,,0‡
12124 M7 12508 01300 2200         BN     YBIGER,,0‡
                     2210  * -DEL TAX    GREATER THAN DELTAY-‡
12136 2Q 00096 14903 2220         LD     96,ABSDY,1‡
12148 2R 00097 14897 2230         D      97,ABSDX,1‡
12160 32 00091 00000 2240         SF     91‡
12172 K6 13943 00093 2250         TF     RATIO,93,0,        RATIO DELTAY/DELTAX‡
12184 M9 12880 00000 2260         B      OK,,0‡
                     2270  * -DEL TAX    GREATER THAN DELTAY-‡
12196 KO 13923 14884 2280         TF     XCNTR,DELTAX-1,01, SET XCOUNTER EQUAL TO DELTAX‡
12208 KJ 13935 13943 2290  GO2    A      XYCNTR,RATIO,01,   MODIFY XYCOUNTER ADDING RATIO‡
12220 ML 12460 13932 2300         BD     GOXY1,XYCNTR-3,01, TEST FOR DIGIT IN XYCOUNTER‡
12232 38 00000 00200 2310         WNPT    ‡
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I-ADD OP                  P/L LABEL   OP      OPERANDS

12238     00005          2320  XOUT    DS     5,*-5‡
12244 J2 13923 000-1 2330  G03     SM     XCNTR,1,010‡
12256 J4 13923 -0000 2340          CM     XCNTR,0,07,         TEST FOR LAST MOVE‡
12268 M6 12208 01100 2350          BP     G02,,0‡
                         2360  * -FIN AL A  DJUSTMENT IN THE Y DIRECTION-‡
12280 MM 12376 14891 2370          BNF    *&96,DELTAY,01,     TEST FOR NEGATIVE DELTAY‡
                         2380  * -NEG ATIV  E DELTAY-‡
12292 KM 14890 13928 2390          C      DELTAY-1,YCNTR-1,01,TEST FOR FINAL ADJUSTMENT‡
12304 M6 13048 01200 2400          BE     CLEAR,,0‡
12316 M7 12352 01300 2410          BN     *&36,,0‡
12328 L8 14536 00200 2420          WNPT   FIVEO-1,,0‡
12340 M9 13048 00000 2430          B      CLEAR,,0‡
12352 L8 14080 00200 2440          WNPT   ONESO-1,,0‡
12364 M9 13048 00000 2450          B      CLEAR,,0‡
                         2460  * -POS ITIV  E DELTAY-‡
12376 KM 14890 13928 2470          C      DELTAY-1,YCNTR-1,01,TEST FOR FINAL ADJUSTMENT‡
12388 M6 13048 01200 2480          BE     CLEAR,,0‡
12400 M7 12436 01300 2490          BN     *&36,,0‡
12412 L8 14080 00200 2500          WNPT   ONESO-1,,0‡
12424 M9 13048 00000 2510          B      CLEAR,,0‡
12436 L8 14536 00200 2520          WNPT   FIVEO-1,,0‡
12448 M9 13048 01200 2530          B      CLEAR,,0‡
                         2540  * -DIG IT I  N XYCOUNTER %DELTAX GRATER THAN DELTAY¤-‡
12460 38 00000 00200 2550  GOXY1   WNPT    ‡
12466     00005          2560  XYOUT   DS     5,*-5‡
12472 J2 13935 0J000 2570          SM     XYCNTR,1000,08‡
12484 J1 13929 000J0 2580          AM     YCNTR,10,010‡
12496 M9 12244 00000 2590          B      G03,,0‡
                         2600  * -DEL TAY   LARGER THAN DELTAX-‡
12508 2Q 00096 14897 2610  YBIGER  LD     96,ABSDX,1‡
12520 2K 00097 14903 2620          D      97,ABSDY,1‡
12532 32 00091 00000 2630          SF     91‡
12544 K6 13943 00093 2640          TF     RATIO,93,0‡
12556 M9 12880 00000 2650          B      OK,,0‡
                         2660  * DELT AY L  ARGER THAN DELTAX‡
12568 K0 13929 14890 2670          TF     YCNTR,DELTAY-1,01,  SET YCOUNTER EQUAL TO DELTAY‡
12580 KJ 13935 13943 2680  G04     A      XYCNTR,RATIO,01,    MODIFY XYCOUNTER ADDING RATIO‡
12592 ML 12832 13932 2690          BD     GOXY2,XYCNTR-3,01,  TEST FOR DIGIT IN XYCOUNTER‡
```

1.0.0-2

```
I-ADD OP                  P/L LABEL   OP      OPERANDS

12604 38 00000 00200 2700             WNPT     *
12610    00005       2710  YOUT       DS      5,*-5*
12616 J2 13929 000-1 2720  G05        SM      YCNTR,1,010*
12628 J4 13929 -0000 2730             CM      YCNTR,0,07,        TEST FOR LAST MOVE*
12640 M6 12580 01100 2740             BP      G04,,0*
                     2750  * -FIN     AL A    DJUSTMENT IN THE X DIRECTION-*
12652 MM 12748 14885 2760             BNF     *&96,DELTAX,01,    TEST FOR NEGATIVE DELTAX*
                     2770  * -NEG     ATIV    E DELTAX-*
12664 KM 14884 13922 2780             C       DELTAX-1,XCNTR-1,01,TEST FOR FINAL ADJUSTMENT*
12676 M6 13048 01200 2790             BE      CLEAR,,0*
12688 M7 12724 01300 2800             BN      *&36,,0*
12700 L8 14764 00200 2810             WNPT    SEVSO-1,,0*
12712 M9 13048 00000 2820             B       CLEAR,,0*
12724 L8 14308 00200 2830             WNPT    THREO-1,,0*
12736 M9 13048 00000 2840             B       CLEAR,,0*
                     2850  * -POS     ITIV    E DELTAX-*
12748 KM 14884 13922 2860             C       DELTAX-1,XCNTR-1,01,TEST FOR FINAL ADJUSTMENT*
12760 M6 13048 01200 2870             BE      CLEAR,,0*
12772 M7 12808 01300 2880             BN      *&36,,0*
12784 L8 14308 00200 2890             WNPT    THREO-1,,0*
12796 M9 13048 00000 2900             B       CLEAR,,0*
12808 L8 14764 00200 2910             WNPT    SEVSO-1,,0*
12820 M9 13048 01200 2920             B       CLEAR,,0*
                     2930  * -DIG     IT I    N XYCOUNTER %DELTAY LARGER THAN DELTAX¤-*
12832 38 00000 00200 2940  GOXY2      WNPT     *
12844 J2 13935 -1000 2950             SM      XYCNTR,1000,07*
12856 J1 13923 000J0 2960             AM      XCNTR,10,010*
12868 M9 12616 00000 2970             B       G05,,0*
                     2980  * -DEL     TAX     EQUAL TO DELTAY-*
12880 PJ 14882 14885 2990  OK         MF      DELTAX-3,DELTAX,01*
12892 J1 14885 000-5 3000             AM      DELTAX,5,010,      ROUND OFF DELTAX*
12904 J5 14885 00000 3010             TDM     DELTAX,0,0*
12916 PJ 14885 14882 3020             MF      DELTAX,DELTAX-3,01*
12928 KJ 13949 14885 3030             A       X0,DELTAX,01,      ADJUST X0*
12940 PJ 14888 14891 3040             MF      DELTAY-3,DELTAY,01*
12952 J1 14891 000-5 3050             AM      DELTAY,5,010,      ROUND OFF DELTAY*
12964 J5 14891 00000 3060             TDM     DELTAY,0,0*
12976 PJ 14891 14888 3070             MF      DELTAY,DELTAY-3,01*
```

1.0.0.2

```
I-ADD OP                  P/L LABEL   OP      OPERANDS

12988 KJ 13955 14891 3080             A       Y0,DELTAY,01,        ADJUST Y0‡
13000 KM 14884 14890 3090             C       DELTAX-1,DELTAY-1,01,TEST FOR LARGER INCREMENT‡
13012 M7 12568 01300 3100             BN      G04-12,,0‡
13024 M6 13096 01200 3110             BE      XYGO,,0‡
13036 M9 12196 00000 3120             B       G02-12,,0‡
                     3130 * -CLE      AR X    COUNTER AND YCOUNTER TO ZEROS AND SET XYCOUNTER #.005 -‡
13048 J6 13935 -0005 3140 CLEAR       TFM     XYCNTR,5,07‡
13060 KO 13923 13917 3150             TF      XCNTR,ZERO1,01‡
13072 KO 13929 13917 3160             TF      YCNTR,ZERO1,01‡
13084 42 00000 00000 3170             BB       ‡
                     3180 * DELT      AX E    QUAL TO DELTAY‡
13096 KO 13246 12466 3190 XYGO        TF      FILL1,XYOUT,01‡
13108 J2 12466 000J1 3200             SM      XYOUT,11,010‡
13120 KO 13306 12466 3210             TF      FILL2,XYOUT,01‡
13132 J2 12466 00J01 3220             SM      XYOUT,101,09‡
13144 KO 13366 12466 3230             TF      FILL3,XYOUT,01‡
13156 KO 13414 12466 3240             TF      FILL4,XYOUT,01‡
13168 KO 13922 14884 3250             TF      XCNTR-1,DELTAX-1,01,SET XCOUNTER EQUAL TO DELTAX‡
13180 ML 13396 13919 3260 FAST        BD      TENS,XCNTR-4,01,     TEST FOR DIGIT IN THE TENS POSITION‡
13192 ML 13336 13920 3270             BD      UNITS,XCNTR-3,01,    TEST FOR DIGIT IN THE UNITS POSIT.‡
13204 ML 13276 13921 3280             BD      TENTHS,XCNTR-2,01,   TEST FOR DIGIT IN THE 1/10 POSIT.‡
13216 J4 13922 -0000 3290 LAST        CM      XCNTR-1,0,07,        TEST FOR LAST SINGLE MOVE‡
13228 M7 13048 01100 3300             BNP     CLEAR,,0‡
13240 38 00000 00200 3310             WNPT     ‡
13246    00005       3320 FILL1       DS      5,*-5‡
13252 J2 13922 000-1 3330             SM      XCNTR-1,1,010‡
13264 M9 13216 00000 3340             B       LAST,,0‡
13276 J4 13921 0-000 3350 TENTHS      CM      XCNTR-2,0,08,        TEST FOR LAST 1/10 INCH MOVE‡
13288 M7 13216 01100 3360             BNP     LAST,,0‡
13300 38 00000 00200 3370             WNPT     ‡
13306    00005       3380 FILL2       DS      5,*-5‡
13312 J2 13921 000-1 3390             SM      XCNTR-2,1,010‡
13324 M9 13276 00000 3400             B       TENTHS,,0‡
13336 J4 13920 00-00 3410 UNITS       CM      XCNTR-3,0,09,        TEST FOR LAST ONE INCH MOVE‡
13348 M7 13276 01100 3420             BNP     TENTHS,,0‡
13360 38 00000 00200 3430             WNPT     ‡
13366    00005       3440 FILL3       DS      5,*-5‡
13372 J2 13920 000-1 3450             SM      XCNTR-3,1,010‡
```

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1.0.0-2

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I-ADD OP                P/L LABEL   OP      OPERANDS

13384 M9 13336 00000 3460           B     UNITS,,0‡
13396 J2 13920 000-1 3470  TENS     SM    XCNTR-3,1,010‡
13408 38 00000 00200 3480           WNPT   ‡
13414    00005       3490  FILL4    DS    5,*-5‡
13420 M9 13180 00000 3500           B     FAST,,0‡
                     3510  * -DEL   TAX   EQUAL ZERO-‡
13432 KM 14903 14962 3520  NEXT5    C     ABSDY,TOLER,01,    TEST FOR ABSDY LESS THAN .005‡
13444 M6 13468 01100 3530           BP    *&24,,0‡
13456 M9 13048 00000 3540           B     CLEAR,,0‡
13468 KM 14891 13917 3550           C     DELTAY,ZERO1,01,   TEST FOR DELTAY EQUAL ZERO‡
13480 M6 13576 01100 3560           BP    NEXT55,,0‡
                     3570  * -DEL   TAX   EQUAL ZERO AND NEGATIVE DELTAY-‡
13492 J0 13246 J4536 3580           TFM   FILL1,FIVEO-1,017‡
13504 J0 13306 J4525 3590           TFM   FILL2,FIVET-10,017‡
13516 J0 13366 J4424 3600           TFM   FILL3,FIVEH-49,017‡
13528 J0 13414 J4424 3610           TFM   FILL4,FIVEH-49,017‡
13540 J2 14891 000-5 3620           SM    DELTAY,5,010,      ROUND OFF DELTAY‡
13552 J5 14891 0000- 3630           TDM   DELTAY,,011‡
13564 M9 13648 00000 3640           B     NEXTY,,0‡
                     3650  * -DEL   TAX   EQUAL ZERO AND POSITIVE DELTAY-‡
13576 J0 13246 J4080 3660  NEXT55   TFM   FILL1,ONESO-1,017‡
13588 J0 13306 J4069 3670           TFM   FILL2,ONEST-10,017‡
13600 J0 13366 J3968 3680           TFM   FILL3,ONESH-49,017‡
13612 K0 13414 13366 3690           TF    FILL4,FILL3,01‡
13624 J1 14891 000-5 3700           AM    DELTAY,5,010,      ROUND OFF DELTAY‡
13636 J5 14891 00000 3710           TDM   DELTAY,0,0‡
13648 K0 13922 14890 3720  NEXTY    TF    XCNTR -1,DELTAY-1,01,SET XCOUNTER EQUAL TO DELTAY‡
13660 KJ 13955 14891 3730           A     Y0,DELTAY,01,      ADJUST Y0‡
13672 M9 13180 00000 3740           B     FAST,,0‡
                     3750  * -DEL   TAY   EQUAL ZERO-‡
13684 MM 13804 14885 3760  NEXT6    BNF   NEXT66,DELTAX,01,  TEST FOR NEGATIVE DELTAX‡
                     3770  * -DEL   TAY   EQUAL ZERO AND NEGATIVE DELTAX-‡
13696 J2 14885 000-5 3780           SM    DELTAX,5,010,      ROUND OFF DELTAX‡
13708 J5 14885 0000- 3790           TDM   DELTAX,0,011‡
13720 J0 13246 J4764 3800           TFM   FILL1,SEVSO-1,017‡
13732 J0 13306 J4753 3810           TFM   FILL2,SEVST-10,017‡
13744 J0 13366 J4652 3820           TFM   FILL3,SEVSH-49,017‡
13756 K0 13414 13366 3830           TF    FILL4,FILL3,01‡
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I-ADD OP                  P/L LABEL   OP      OPERANDS

13768 KO 13922 14884 3840             TF     XCNTR-1,DELTAX-1,01,SET XCOUNTER EQUAL TO DELTAX‡
13780 KJ 13949 14885 3850             A      X0,DELTAX,01,       ADJUST X0‡
13792 M9 13180 00000 3860             B      FAST,,0‡
                     3870   * -DEL  TAY    EQUAL ZERO AND POSITIVE DELTAX-‡
13804 J0 13246 J4308 3880   NEXT66  TFM    FILL1,THREO-1,017‡
13816 J0 13306 J4297 3890           TFM    FILL2,THRET-10,017‡
13828 J0 13366 J4196 3900           TFM    FILL3,THREH-49,017‡
13840 KO 13414 13366 3910           TF     FILL4,FILL3,01‡
13852 J1 14885 000-5 3920           AM     DELTAX,5,010,       ROUND OFF DELTAX‡
13864 J5 14885 00000 3930           TDM    DELTAX,0,0‡
13876 KO 13922 14884 3940           TF     XCNTR-1,DELTAX-1,01,SET XCOUNTER EQUAL TO DELTAX‡
13888 KJ 13949 14885 3950           A      X0,DELTAX,01,       ADJUST X0‡
13900 M9 13180 00000 3960           B      FAST,,0‡
13917    00006       3970   ZERO1   DC     6,0‡
39700-00000‡                                                    -6J3912J3918-
13923    00006       3980   XCNTR   DC     6,0‡
39800-00000‡                                                    -6J3918J3924-
13929    00006       3990   YCNTR   DC     6,0‡
39900-00000‡                                                    -6J3924J3930-
13935    00006       4000   XYCNTR  DC     6,5‡
40000-00005‡                                                    -6J3930J3936-
13943    00008       4010   RATIO   DS     8‡
13949    00006       4020   X0      DS     6,,,                X VALUE OF THE PEN AFTER EACH MOVE‡
13955    00006       4030   Y0      DS     6,,,                Y VALUE OF THE PEN AFTER EACH MOVE‡
13961    00006       4040   X1      DS     6,,,                COORDINATE X OF THE NEW POINT‡
13967    00006       4050   Y1      DS     6,,,                COORDINATE Y OF THE NEW POINT‡
14017    00050       4060   ONESH   DC     50,1111111111111111111111111111111111111111111111‡
40600J11111111111111111111111111111111111111111111111‡          -6J3968J4018-
14067    00050       4070           DC     50,1111111111111111111111111111111111111111111111‡
40700J11111111111111111111111111111111111111111111111‡          -6J4018J4068-
14068    00001       4080           DC     1,@‡
40800‡                                                          -6J4068J4069-
14079    00011       4090   ONEST   DC     11,1111111111@‡
40900J111111111‡                                                -6J4069J4080-
14081    00002       4100   ONESO   DC     2,1@‡
41000J‡                                                         -6J4080J4082-
14131    00050       4110   TWOSH   DC     50,2222222222222222222222222222222222222222222222‡
41100K22222222222222222222222222222222222222222222222‡          -6J4082J4132-
```

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1.0.0-2

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I-ADD OP                  P/L LABEL   OP       OPERANDS

14181     00050      4120             DC    50,22222222222222222222222222222222222222222222222222*
41200K22222222222222222222222222222222222222222222222222*     -6J4132J4182-
14182     00001      4130             DC    1,@*
41300*                                                          -6J4182J4183-
14193     00011      4140   TWOST     DC    11,2222222222@*
41400K222222222*                                                -6J4183J4194-
14195     00002      4150   TWOSO     DC    2,2@*
41500K*                                                         -6J4194J4196-
14245     00050      4160   THREH     DC    50,33333333333333333333333333333333333333333333333333*
41600L33333333333333333333333333333333333333333333333333*     -6J4196J4246-
14295     00050      4170             DC    50,33333333333333333333333333333333333333333333333333*
41700L33333333333333333333333333333333333333333333333333*     -6J4246J4296-
14296     00001      4180             DC    1,@*
41800*                                                          -6J4296J4297-
14307     00011      4190   THRET     DC    11,3333333333@*
41900L333333333*                                                -6J4297J4308-
14309     00002      4200   THREO     DC    2,3@*
42000L*                                                         -6J4308J4310-
14359     00050      4210   FOURH     DC    50,44444444444444444444444444444444444444444444444444*
42100M44444444444444444444444444444444444444444444444444*     -6J4310J4360-
14409     00050      4220             DC    50,44444444444444444444444444444444444444444444444444*
42200M44444444444444444444444444444444444444444444444444*     -6J4360J4410-
14410     00001      4230             DC    1,@*
42300*                                                          -6J4410J4411-
14421     00011      4240   FOURT     DC    11,4444444444@*
42400M444444444*                                                -6J4411J4422-
14423     00002      4250   FOURO     DC    2,4@*
42500M*                                                         -6J4422J4424-
14473     00050      4260   FIVEH     DC    50,55555555555555555555555555555555555555555555555555*
42600N55555555555555555555555555555555555555555555555555*     -6J4424J4474-
14523     00050      4270             DC    50,55555555555555555555555555555555555555555555555555*
42700N55555555555555555555555555555555555555555555555555*     -6J4474J4524-
14524     00001      4280             DC    1,@*
42800*                                                          -6J4524J4525-
14535     00011      4290   FIVET     DC    11,5555555555@*
42900N555555555*                                                -6J4525J4536-
14537     00002      4300   FIVEO     DC    2,5@*
43000N*                                                         -6J4536J4538-
```

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1.0.0-2

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I-ADD OP               P/L LABEL   OP      OPERANDS

14587   00050      4310  SIXSH  DC    50,666666666666666666666666666666666666666666#
431000666666666666666666666666666666666666666666#          -6J4538J4588-
14637   00050      4320         DC    50,666666666666666666666666666666666666666666#
432000666666666666666666666666666666666666666666#          -6J4588J4638-
14638   00001      4330         DC    1,@#
43300#                                                     -6J4638J4639-
14649   00011      4340  SIXST  DC    11,6666666666@#
434000666666666#                                           -6J4639J4650-
14651   00002      4350  SIXSO  DC    2,6@#
435000#                                                    -6J4650J4652-
14701   00050      4360  SEVSH  DC    50,777777777777777777777777777777777777777777#
43600P77777777777777777777777777777777777777777#           -6J4652J4702-
14751   00050      4370         DC    50,777777777777777777777777777777777777777777#
43700P77777777777777777777777777777777777777777#           -6J4702J4752-
14752   00001      4380         DC    1,@#
43800#                                                     -6J4752J4753-
14763   00011      4390  SEVST  DC    11,7777777777@#
43900P777777777#                                           -6J4753J4764-
14765   00002      4400  SEVSO  DC    2,7@#
44000P#                                                    -6J4764J4766-
14815   00050      4410  EIGHH  DC    50,888888888888888888888888888888888888888888#
44100Q88888888888888888888888888888888888888888#           -6J4766J4816-
14865   00050      4420         DC    50,888888888888888888888888888888888888888888#
44200Q88888888888888888888888888888888888888888#           -6J4816J4866-
14866   00001      4430         DC    1,@#
44300#                                                     -6J4866J4867-
14877   00011      4440  EIGHT  DC    11,8888888888@#
44400Q888888888#                                           -6J4867J4878-
14879   00002      4450  EIGHO  DC    2,8@#
44500Q#                                                    -6J4878J4880-
14885   00006      4460  DELTAX DS    6,,,             INCREMENT IN THE X DIRECTION#
14891   00006      4470  DELTAY DS    6,,,             INCREMENT IN THE Y DIRECTION#
14897   00006      4480  ABSDX  DS    6,,,             ABSOLUTE VALUE OF DELTAX#
14903   00006      4490  ABSDY  DS    6,,,             ABSOLUTE VALUE OF DELTAY#
14906   00003      4510  PENDWN DC    3,0@#
45100-0#                                                   -6J4904J4907-
14909   00003      4520  PENUP  DC    3,9@#
45200-9#                                                   -6J4907J4910-
```

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10.0.9

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I-ADD OP                   P/L LABEL   OP       OPERANDS

14911     00002       4530  EX2     DC      2,2*
45300-2*                                                    -6J4910J4912-
14913     00002       4540  EX0     DC      2,0*
45400-0*                                                    -6J4912J4914-
14915     00002       4550  EX      DC      2,-9-9*
45500RR*                                                    -6J4914J4916-
14917     00002       4560  EXM2    DC      2,-2*
45600-K*                                                    -6J4916J4918-
14923     00006       4570  AX      DS      6,,,          INITIAL ADRESS OF X*
14929     00006       4580  AY      DS      6,,,          INITIAL ADRESS OF Y*
00485     00003       4590  FAC     DS      3,485,,       FLOATING ACCUMULATOR*
09999     00004       4600  ARG     DS      4,9999,,      ARGUMENT*
00402     00003       4610  FF      DS      3,402,,       FLOATING POINT FIELD LENGTH*
14959     00030       4620  Y       DC      30,0*
46200-000000000000000000000000000*                          -6J4930J4960-
14962     00003       4630  TOLER   DC      3,5,,         TOLERENCE OF .005 INCH*
46300-05*                                                   -6J4960J4963-
14967     00005       4640  CO      DC      5,0*
46400-0000*                                                 -6J4963J4968-
10000                 4650          DEND    10000*
46500   L60000000500490000*                                 -8-0096-0115-
36001000050036001720050036002440050036003160050036000000500     -
00000000000102030400020406080003060902100408021610050015102006021814200* -
704112820080614223009081726300000000005060708090012141618151811242720242* -
822363520353045403632484455324946536048465462754453627180123456789123456* -
789-23456789-J3456789-JK456789-JKL56789-JKLM6789-JKLMN789-JKLMN089-JKLMN* -
M800000000049J00000P9-JKLMNOPQ*    L10038800019M9000000000M90003600000  -
```

Appendix G

PROGRAM FOR SHELL DEVELOPMENT FOR SHIPS' HULLS

CONTENTS

Section I

INTRODUCTION

This report gives a detailed description of the input/output, operating instructions, and computing procedures (flow diagram) of a shell development program.

The program was written to provide a more accurate and economical method of developing shell plate than the graphical method now employed by the shipbuilding industry.

The development is made from a table of final lofted offsets which locate the plate on the hull surface. With these offsets, the program computes a set of two-dimensional coordinates which represent points on the perimeter of the plate at each frame. These points, when plotted and faired, can be used as a pattern for cutting the shell plate.

The program is written in FORTRAN for an IBM-1620 computer.

Section II

THE PROBLEM

The process of developing shell plate separates into two distinct portions:

(1) Calculating the true lengths of line segments on the hull surface

(2) Assembling these calculated line segments into the shape of the plate to be cut.

The information necessary to solve the problem is a complete table of offsets, including those at the plate sight edges.

FINDING THE TRUE LENGTH OF THE LINE SEGMENTS

Since the equation of the hull surface is unknown, the equation for each line segment is also unknown. The curve must, therefore be approximated by passing a known function through the data points. The length of the known curve in that interval may then be found.

The method which is presented is independent of this approximating function. Because the equation for passing a circle through the given points is simple and convenient to calculate, circles were used for this purpose. Other functions, such as parabolas, could be easily substituted.

Any three points in three-dimensional space are co-planner. For this reason it is most convenient to fit the approximating function to groups of three offsets at a time.

This equation is most accurate if the plane passing through the three points is very nearly perpendicular to the center plane of the ship, i.e., the projection on the centerline plane of a line passing through the three points is nearly straight. This condition is met by points

along frame lines and along plate sight edges.

In finding the length of lines such as Line 7 of Fig. 1 (Page G-12 of this Appendix), this condition is only rarely met. Usually the coordinates of the line of Points $B_1 \ldots B_i$ are much closer to one edge of the plate than to the other edge. In this situation the plane passing through the points necessary to find the arc length (Points C_0 , B_1 , A_2 for Line 7) intersects the centerplane at some angle very different than 90°. A circle passing through these three points would project as an arc on the centerplane. The length of the line obtained would be in error by the amount the projected arc exceeds the length of projected straight lines between the points.

For this reason, the shell plate for finding the length of these lines is assumed to be a cylinder, and the arc length found using the method of Section IV of this Appendix.

Establishing the Flat Plate Contour

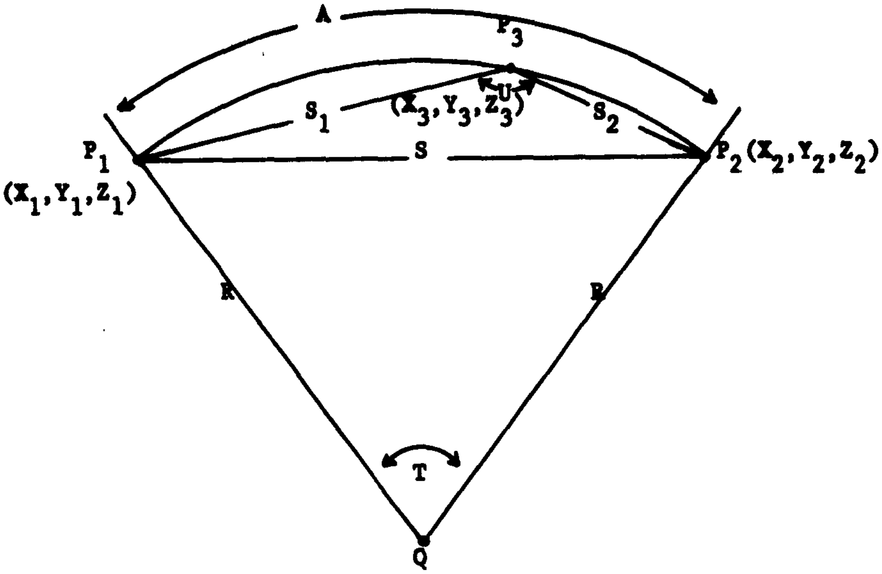
Once the true lengths of the curves have been found, they must be assembled to accurately determine the shape of the flat plate. This procedure is accomplished by triangulation (See Fig. 1, Page G-12). Since the lengths of the three sides of each of the triangles are known, the triangles are completely determined. The procedure then becomes that of assembling these triangles and solving for the coordinates of points on the periphery of the plate which determine its shape.

An outline of this procedure is given in Section V.

Section III

EQUATIONS FOR PASSING A CIRCLE THROUGH 3 POINTS

Length of the circular arc constructed through three arbitrary points



Objective: Determine the length of the arc A given only the coordinates of the three points P_1 , P_2 , P_3 .

S_1 , S_2 , S_3 can be calculated from the well-known formula for the distance between two points, i.e.,

$$S_1 = \sqrt{(X_3-X_1)^2 + (Y_3-Y_1)^2 + (Z_3-Z_1)^2}$$

$$S_2 = \sqrt{(X_2-X_3)^2 + (Y_2-Y_3)^2 + (Z_2-Z_2)^2}$$

$$S_3 = \sqrt{(X_2-X_1)^2 + (Y_2-Y_1)^2 + (Z_2-Z_1)^2}$$

For the present, assume R (Radius of Circle through P_1 , P_2 , P_3) is known.

The problem now becomes: Determine A as a function of S and R only. The length of an arc on a circle is equal to the product of the radius and the central angle determined by the end points of this arc. In the immediate application this implies:

(1) $A = RT$

T must now be expressed in terms of S_3 and R.

Employing the law of cosines with respect to triangle $P_1 Q P_2$, it can readily be seen that:

$$S_3^2 = 2R^2 - 2R^2 \cos (T)$$

or

$$\frac{S_3^2}{2R^2} = 1 - \cos (T)$$

Using the identity $\sin^2(T/2) - 1/2 - 1/2 \cos (T)$

above expression becomes

$$\sin^2 T/2 = S_3^2/4R^2$$

or

$$\sin T/2 = S_3/2R$$

Equivalently

(2) $$T = 2 \sin^{-1} S_3/2R$$

Combining (1) and (2) the expression for A in terms of S_3 and R is obtained:

(3) $$A = 2R \sin^{-1} \frac{S_3}{2R}$$

Using a trigonometric series:

(4) $$\mathrm{Sin}^{-1}(X) = X + \frac{X^3}{6} + \frac{1\cdot3\cdot X^5}{2\cdot4\cdot5} + \frac{1\cdot3\cdot5\cdot X^7}{2\cdot4\cdot6\cdot7} + \frac{1\cdot3\cdot5\cdot7\cdot X^9}{2\cdot4\cdot6\cdot8\cdot9} + \frac{1\cdot3\cdot5\cdot7\cdot9\cdot X^{11}}{2\cdot4\cdot6\cdot8\cdot10\cdot11}$$

The argument X must now be expressed in terms of S_3 and R. Utilizing law of sines with respect to $U\ P_1\ P_2\ P_3$:

$$\frac{S_3}{\mathrm{SinU}} = \text{Diameter of circumscribed circle}$$

$$\therefore \quad \frac{S_3}{\mathrm{SinU}} = ZR$$

(5) $$\frac{1}{R} = \frac{2\mathrm{SinU}}{S_3}$$

Using law of cosines with respect to $U\ P_1\ P_2\ P_3$:

$$S_3^2 = S_2^2 + S_1^2 - 2S_1\ S_3\ \mathrm{Cos}\ U$$

$$\mathrm{Cos}\ U = \frac{S_2^2 + S_1^2 - S_3^2}{2S_1\ S_2}$$

also

$$\mathrm{Sin}^2U = 1-\mathrm{Cos}^3U$$

(6) $$\mathrm{Sin}^2U = 1 - \frac{\left(S_2^2 + S_1^2 - S_3^2\right)^2}{4S_1^2\ S_2^2}$$

Combining (5) and (6)

$$\frac{1}{R} = \sqrt{\frac{4S_1^2\ S_2^2 - \left(S_2^2 + S_1^2 - S_3^2\right)^2}{S_1^2\ S_2^2\ S_3^2}}$$

(7) Let $X = \left(\frac{S_3}{R}\right)^2$

(8) $$X = S_3^2 \quad \frac{\left[4S_1^2\, S_2^2 - \left(S_2^2 + S_1^2 - S_3^2\right)^2\right]}{S_1^2\, S_2^2\, S_3^2}$$

Combining (3), (4), and (7), the final expression for arc length becomes:

(9) $$A = S_3\left(1 + \frac{X}{24} + \frac{3}{640}X^2 + \frac{5}{7168}X^3 + \frac{35}{48\cdot 48\cdot 128}X^4 + \frac{63}{2816\cdot 32\cdot 32}X^5\right)$$

Replacing S_3 by S_1 in (8) and (9) would give the arc length between P_1 and P_3, etc.

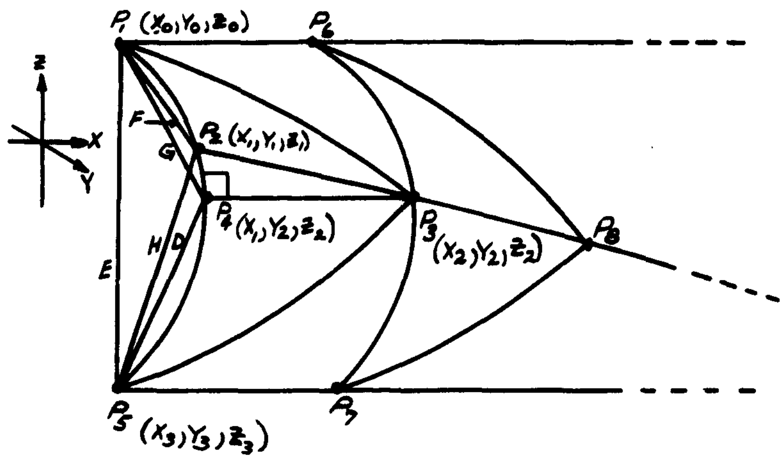
SECTION IV

DIAGONAL ARC LENGTH APPROXIMATION

The following describes the method used to find the arc lengths of certain lines (See Fig. I, lines 3, 7, 10, 11 of Section V).

Known: P_1 , P_2 , P_3 , P_5

$X_o = X_1 = X_3$



$E = \sqrt{(Y_3-Y_0)^2+(Z_3-Z_0)^2}$; $F = \sqrt{(Y_1-Y_0)^2+(Z_1-Z_0)^2}$; $H = \sqrt{(Y_3-Y_1)^2+(Z_3-Z_1)^2}$

(1) $G = \sqrt{(Y_2-Y_0)^2+(Z_2-Z_0)^2}$ (2) $D = \sqrt{(Y_3-Y_2)^2+(Z_3-Z_2)^2}$

$\overline{P_4P_3} = X_2 - X_1$

Knowing lengths of E, F, and H , arc lengths P_1 P_4 and P_4P_5 can be computed using (1) and (2) with the method described in Section III.

Then using the Pythagorean theorem: $P_1P_3 = \sqrt{(P_1P_4)^2+(\overline{P_4P_3})^2}$

$P_5P_3 = \sqrt{(P_4P_5)^2+(\overline{P_4P_3})^2}$

Section V

OUTLINE OF THE ANALYTIC PROCEDURE FOR ESTABLISHING THE FLAT PLATE CONTOUR

In Fig. 1; Line C_o, C_1, ... , C_i, and Line A_o, A_1, ... , A_i are on the upper and lower sight edges of the plate; Line B_o, B_1, ... , is either a waterline or buttock line which passes reasonably close to the mean line between the sight edges.

The following assumes the coordinates of Points A_o, ... , A_i; B_o, ... , B_i; C_o, ... , C_i are known on the ship's hull (heights and half-breadths), and also assumes that the arc lengths between the points have been calculated using Appendix I-A, or some similar method.

B_o is the plate origin (See Fig. 1) and its coordinates are therefore known. Line $\overline{B_oB_1}$ is assumed to be parallel to the X axis

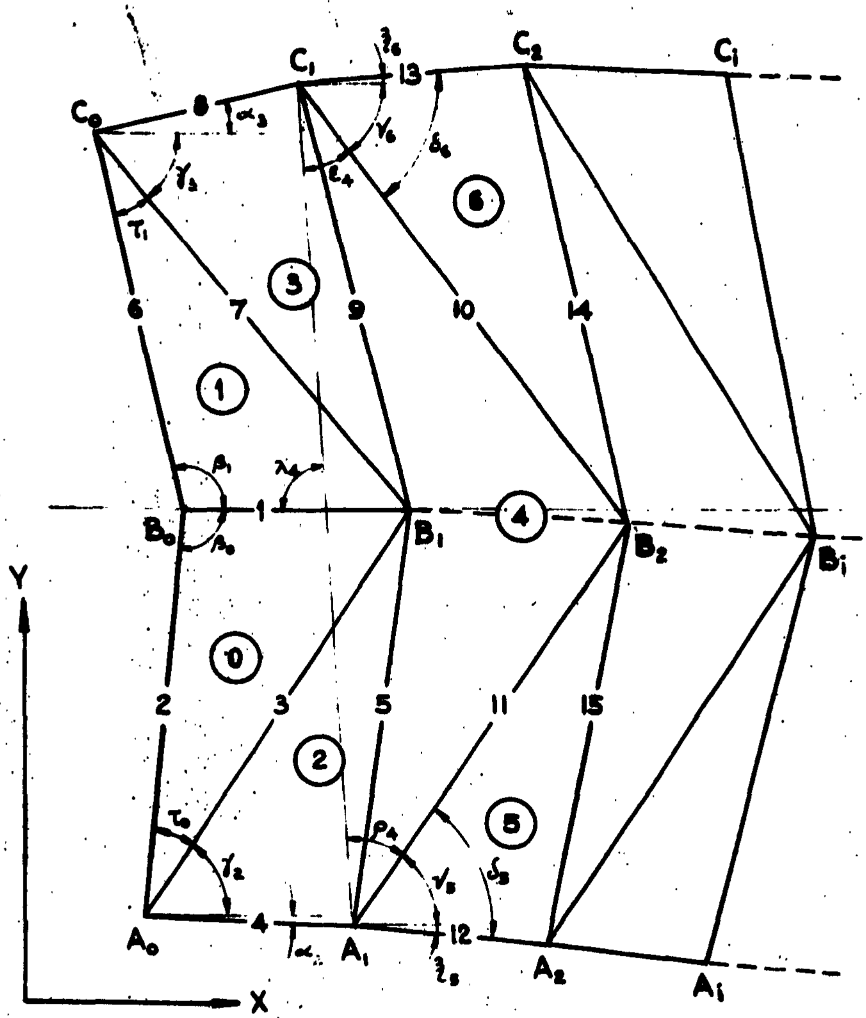
$\overline{B_oB_1}$, $\overline{B_oA_o}$, $\overline{B_1A_o}$ are known

$$S_o = \frac{1}{2}\left(\overline{B_oB_1} + \overline{B_oA_o} + \overline{B_1A_o}\right)$$

$$r_o = \frac{1}{2}\left[\left(S_o - \overset{+}{\overline{B_oB_1}}\right)\left(S_o - \overline{B_oA_o}\right)\left(S_o - \overline{B_1A_o}\right)\right]^{\frac{1}{2}}$$

$$\cos\beta_o = \frac{\left(\overline{B_oB_1}\right)^2 + \left(\overline{B_oA_o}\right)^2 - \left(\overline{B_1A_o}\right)^2}{2\left(\overline{B_oA_o}\right)\left(\overline{B_oB_1}\right)}$$

$$\left.\begin{aligned} A_{oy} &= \frac{2r_os_o}{\overline{B_oB_1}} \\ A_{ox} &= \overline{B_oA_o}\cos\beta_o \end{aligned}\right\}\ \text{Coordinates of Point } A_o$$



Note: Circled numbers indicate order that triangles are used in triangulation process.

Fig. 1 Method of Plate Segmentation for Lofting by Triangulation

$$\tau_o = \text{Arctan} \left[\frac{\dfrac{2r_o}{S_o - \overline{B_oB_1}}}{1 - \left(\dfrac{r_o}{S_o - \overline{B_o B_1}} \right)^2} \right]$$

$\overline{B_oC_o}$, $\overline{B_1C_o}$ Known

$$S_1 = \frac{1}{2} \left(\overline{B_oB_1} + \overline{B_oC_o} + \overline{B_1C_o} \right)$$

$$r_1 = \left[\frac{1}{S_1} (S_1 - \overline{B_oB_1}) \; (S_1 - \overline{B_oC_o}) \; (S_1 - \overline{C_oB_1}) \right]^{\frac{1}{2}}$$

$$\cos \beta_1 = \frac{(\overline{B_1B_o})^2 + (\overline{B_oC_o})^2 - (\overline{B_1C_o})^2}{2(\overline{B_oB_1}) \; (\overline{B_oC_o})^2}$$

$$\left. \begin{aligned} C_{oy} &= \frac{2r_1S_1}{\overline{B_oB_1}} \\ C_{ox} &= \overline{C_oB_o} \cos \beta_1 \end{aligned} \right\} \text{Coordinates of } C_o$$

$$\tau_1 = \text{Arctan}\left[\frac{\dfrac{2r_1}{S_1 - \overline{B_oB_1}}}{1 - \left(\dfrac{r_1}{S_1 - \overline{B_oB_1}}\right)^2}\right]$$

$$\left.\begin{array}{l} B_1x = \overline{B_oB_1} \\ B_1y = 0_o \end{array}\right\} \quad \text{Coordinates of } B_1$$

A_oA_1 , B_1B_1 known

$$S_2 = \frac{1}{S_2} \left(\overline{B_1A_o} + \overline{A_oA_1} + \overline{A_1B_1}\right)$$

$$r_2 = \left[\frac{1}{S_2} \left(S_2 - \overline{B_1A_o}\right)\left(S_2 - \overline{A_oA_1}\right)\left(S_2 - \overline{A_1B_1}\right)\right]^{\frac{1}{2}}$$

$$\beta_o = \tan^{-1} \frac{A_oX}{A_oY}$$

$$\gamma_2 = \text{Arctan}\left[\frac{\dfrac{2r_2}{S_2 - \overline{B_1A_1}}}{1 - \left(\dfrac{r_2}{S_2 - B_1A_1}\right)^2}\right]$$

$\alpha_2 = 90^\circ - \tau_o - \gamma_2 - \beta_o$, where A_oX is negative

$\alpha_2 = 90^\circ - \tau_o + \beta_o - \gamma_2$, where A_oX is positive or zero

$$\left.\begin{aligned} A_1y &= A_oy + \overline{A_oA_1}\ \sin\alpha_2 \\ A_1x &= A_ox + \overline{A_oA_1}\ \cos\alpha_2 \end{aligned}\right\}\ \text{Coordinates of } A_1$$

$\overline{C_oC_1}$, $\overline{C_1B_1}$ Known

$$S_3 = \frac{1}{2}\left(\overline{B_1C_o} + \overline{C_oC_1} + \overline{C_1B_1}\right)$$

$$r_3 = \frac{1}{S_3}\left[(S_3 - \overline{B_1C_o})\ (S_3 - \overline{C_oC_1})\ (S_3 - \overline{C_1B_1})\right]^{\frac{1}{2}}$$

$$\beta_1 = \tan^{-1}$$

$$\gamma_3 = \text{Arctan}\left[\frac{\dfrac{2r_3}{S_3 - \overline{B_1C_1}}}{1 - \dfrac{r_3}{\left(S_3 - \overline{B_1C_1}\right)^2}}\right]$$

$$\alpha_3 = \eta_1 + \gamma_3 + \beta_1 - 90^\circ\text{, where } C_oX \text{ is negative}$$

$$\alpha_3 = \eta_1 - \beta_1 + \gamma_3 - 90^\circ\text{, where } C_oX \text{ is positive or zero}$$

$$\left.\begin{aligned} C_1y &= C_oy + \overline{C_oC_1}\ \sin\alpha_3 \\ C_1x &= C_ox + \overline{C_oC_1}\ \cos\alpha_3 \end{aligned}\right\}\ \text{Coordinates of } C_1$$

$\overline{C_1B_2}$, $\overline{A_1B_2}$ Known

LOOP

$$\overline{A_1C_1} = \left[(C_1x - A_1x)^2 + (C_1y - A_1y)^2\right]^{\frac{1}{2}}$$

$$\lambda_4 = \frac{\pi}{2}, \text{ where } A_1X = C_1X$$

$$\lambda_4 = \tan^{-1}\left(\frac{C_1Y - A_1Y}{C_1X - A_1X}\right), \text{ where } A_1X < C_1X$$

$$\lambda_4 = 180^\circ - \tan^{-1}\left(\frac{C_1Y - A_1Y}{A_1X - C_1X}\right), \text{ where } A_1X > C_1X$$

$$S_4 = \frac{1}{2}\left(\overline{A_1C_1} + \overline{A_1B_2} + \overline{B_2C_1}\right)$$

$$r_4 = \left[\frac{1}{S_4}\left(S_4 - \overline{A_1C_1}\right)\left(S_4 - \overline{A_1B_2}\right)\left(S_4 - \overline{B_2C_1}\right)\right]^{\frac{1}{2}}$$

$$\rho_4 = \text{Arctan}\left[\frac{\dfrac{24_4}{S_4 - \overline{C_1B_2}}}{1 - \left(\dfrac{4}{S_4 - \overline{C_1B_2}}\right)^2}\right]$$

$$\gamma s_5 = \left(\frac{\pi}{2} - \lambda_4\right) - \rho_4 = \lambda_4 - P_4$$

$$\left.\begin{aligned} B_2y &= A_1y + \overline{A_1B_2}\sin\gamma_5 \\ B_2x &= A_1x + \overline{A_1B_2}\cos\gamma_5 \end{aligned}\right\} \text{ Coordinates of } B_2$$

$\overline{A_1A_2}$, $\overline{A_2B_2}$ Known

$$S_5 = \frac{1}{2}\left(\overline{A_1B_2} + \overline{B_2A_2} + \overline{A_2A_1}\right)$$

$$R_5 + \left[\frac{1}{S_5} \quad (S_5 - \overline{A_1B_2})(S_5 - \overline{B_2A_2})(S_5 - \overline{A_2A_1})\right]$$

$$\delta_5 = \text{Arctan} \left[\frac{\dfrac{2r_5}{S_5 - \overline{B_2A_2}}}{1 - \left(\dfrac{r_5}{S_5 - \overline{B_2A_2}}\right)^2}\right]$$

$$\zeta_5 = \gamma_5 - \delta_5$$

$$\left.\begin{aligned} A_2y &= A_1y + \overline{A_1A_2} \sin \zeta_5 \\ A_2x &= A_1x + \overline{A_1A_2} \cos \zeta_5 \end{aligned}\right\} \quad \text{Coordinates of } A_2$$

$$E_4 = \text{Arctan} \left[\frac{\dfrac{2r_4}{S_4 - \overline{A_1B_2}}}{1 - \left(\dfrac{r_4}{S_4 - A_1B_2}\right)^2}\right]$$

$$\gamma_6 = 180^\circ - \lambda_4 - E_4$$

$\overline{C_1C_2}$, $\overline{C_1B_2}$ Known

$$S_6 = \frac{1}{2}\left(\overline{B_2C_1} + \overline{C_1C_2} + \overline{C_2B_2}\right)$$

$$r_6 = \left[\frac{1}{S_6}\left(S_6 - B_2C_1\right)\left(S_6 - C_1C_2\right)\left(S_6 - C_2B_2\right)\right]^{\frac{1}{2}}$$

$$\delta_6 = \text{Arctan}\left[\frac{\dfrac{2r_6}{S_6 - \overline{B_2C_2}}}{1 - \left(\dfrac{r_6}{S_6 - \overline{B_2C_2}}\right)^2}\right]$$

$$\zeta_6 = \delta_6 - \gamma_6$$

$$\left.\begin{aligned} C_2y &= C_1y + C_1C_2 \sin \zeta_6 \\ C_2x &= C_1x + C_1C_2 \cos \zeta_6 \end{aligned}\right\} \text{Coordinates of } C_2$$

REPEAT FROM LOOP FOR NEXT TRIANGLE, ETC.

Section VI

SHIFT OF SIGHT EDGE

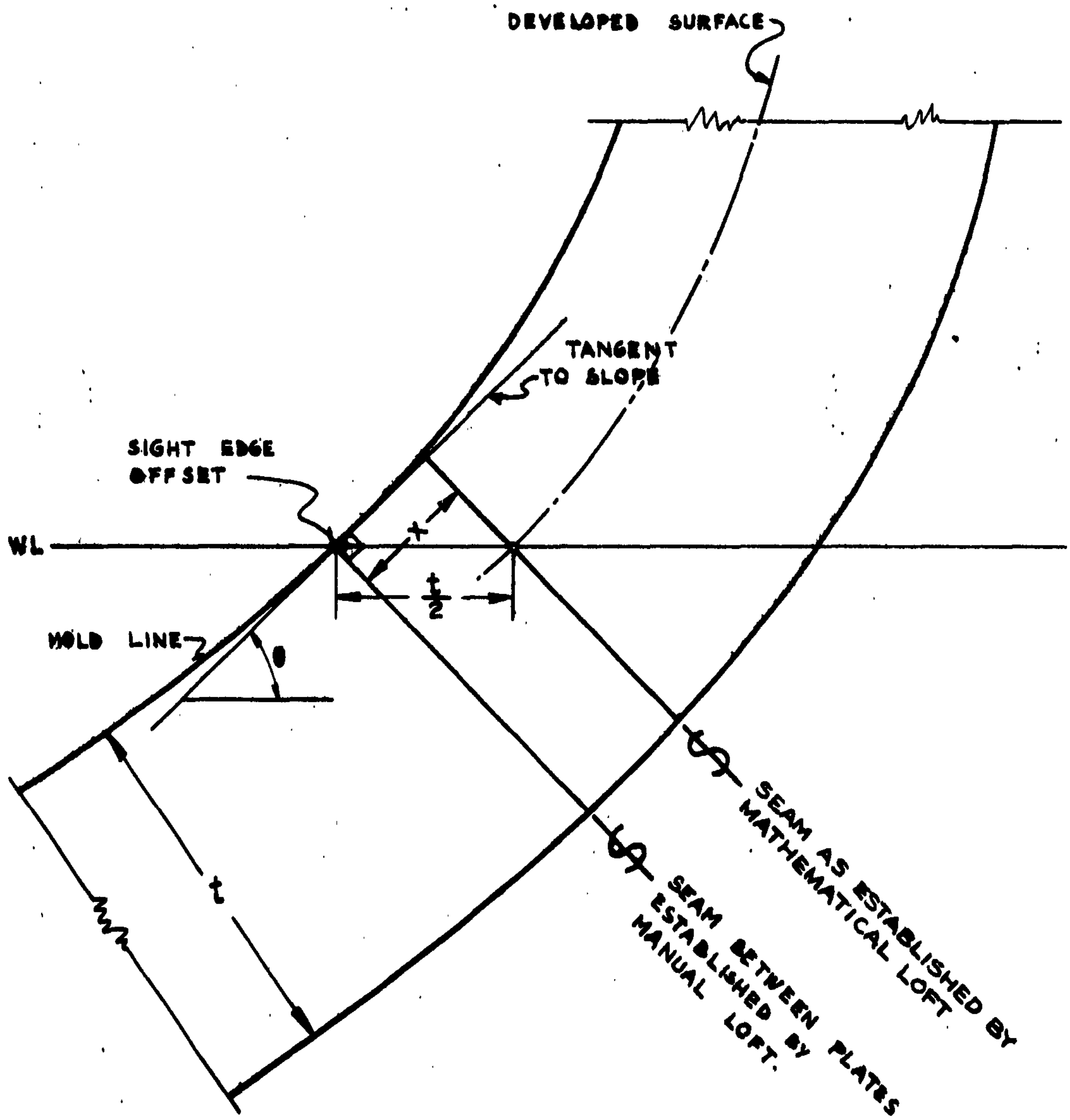
In manual methods of shell plate development, the neutral plane is graphically projected to define the equivalent flat plate pattern. The neutral plane is determined, conventionally, by a point 1/2 t from and normal to the molded line of the plate, where t = plate thickness. This is necessary since the finished mold loft offsets lie on the mold line, which is normally the interior surface of the plate. The point which is the intersection of the plate edge and the mold line is called the sight edge offset, as shown in Fig. G-2.

To exactly duplicate the foregoing in a computer program, calculation of the slope of the curve would be necessary to establish the normal to the plate through the sight edge offset. This complication can be avoided entirely by permitting the final plate sight edge to deviate slightly from that provided by the loft. Of importance is that the deviation in sight edge on one plate is entirely compensated for on the adjoining plate. The plate itself remains in exactly the same position on the hull. Fig. G-2 shows the method employed in the computer program wherein the neutral plane is approximated by finding the point which is $\frac{t}{2}$ from the sight edge offset <u>along the plane of measurement</u>. Whether the projection is to a vertical plane or a horizontal plane depends upon whether the sight edge offset is defined by the mold loft from waterline half breadths or buttock heights, respectively.

It is obvious that no shift of sight edge will occur where the slope of the mold line is either zero or infinite. For all other slopes, the deviation varies as the cosine of the angle of tangency, with maximum deviation occurring when that angle equals forty-five degrees.

In a one-half inch shell plate, the maximum deviation would be slightly less than one-fourth inch. Since such a negligible shift in sight edge permits a substantial simplification in the computer program, its adoption is considered justifiable.

The foregoing is presented in detail, since the computer method produces a result which deviates from conventional lofting methods. This deviation must be known by the loftsman, otherwise it will appear that the computer solution produces a measurable error in some cases, when checked in the loft by conventional methods. Further, if both computer development and manual plate development are done on the same ship, the manual method must conform to the computer method in order to achieve compatibility.



$$\frac{x}{t/2} = \cos\theta \qquad x = \frac{t}{2}\cos\theta = \text{CHANGE IN SEAM BETWEEN METHODS}$$

Fig. G-2 Section Through Plate and Seam

Section VII

INPUT AND OUTPUT

When shell plating is placed on the ship it is butted or joined between frames. Because the offsets are provided on the frames only, the computing methods used in the program require that the offsets be given one frame ahead of the butt at the start of the plate, and for two frames beyond the butt at the other end. This, then, means that for a plate covering twenty frames, offsets for twenty-three frames are needed.

The offsets provided by the loft are given for the upper and lower sight edges, as well as for a waterline or butt line on the plate which passes between the sight edges. The program provides for a maximum plate length of fifty frames and a minimum of two frames.

The offsets are given in feet, inches, eighths, and sixteenths, and are in the form X , Y , and Z , where X is frame spacing, Y is half-breadths, and Z is height. When the plate is on the bottom of the hull, the $\frac{t}{2}$ (detailed above) value must be subtracted from the Z terms. However, the program was written so that $\frac{t}{2}$ is algebraically added to the Y terms; consequently, the X and Z values are reversed on the input data cards, and the $\frac{t}{2}$ input is made negative.

The punched output containing the coordinates is in a format compatible with the input format requirements of an existing program which will plot these points for fairing. However, the coordinate information can readily be used to manually plot the traces of the plates.

Input Format

The card format for X , Y , and Z , is as follows:

feet	inches	8ths	16ths								
I3	I2	I1	I2	I3	I2	I1	I2	I3	I2	I1	I2
X				Z				Y			

A complete input data deck is constructed in the following manner:

The first card is the plate identification, e.g., D-bb7 (I3), B-b14 (I3), D-101 (I3), ... The second card contains the number of frames of the plate (I3 format), and the plate thickness (F7.4 format). The third card will be the start of the offsets, as previously described.

The offsets for the upper edge of the plate must be first in order, followed by the middle line offsets, and finally the offsets for the lower edge.

Output Format

The first card of punched output is the plate identification, which is identical to the first card of input data. The remaining cards are the X-Y coordinates of the plate. The coordinates of the upper edge on every frame are punched first, and then the cooresponding coordinates for the lower edge are punched. The computed coordinates are in inches at one-tenth scale. The cards containing the upper

edge points have a format as follows:

I3	F9.3	I3	F9.3

XU(n)=±XXXX.XXXbYU(n)±XXXX.XXX

XU and YU being X upper and Y upper

The cards for the lower edge have the same format, except XU and YU are replaced by XL and YL (X lower and Y lower).

<u>Operating Instructions for IBM-1620</u>

1. All switches to off and program
2. Clear memory and reset
3. Sense Switch 3 ON, if printout of lengths is desired
4. Load Object Deck and push "Load" Switch on 1622
5. Load Data Deck(s) on command, "load data" message printed by typewriter, and push "reader start" switch on 1622
6. Load Punch Hopper and push "punch start" on 1622
7. Data processing is complete when (a) all data cards have been read properly, (b) output has been punched, and (c) a "reader-no-feed" light on 1620 console
8. A non-process runout of the 1622 card punch must be made to obtain the last-punched output card

<u>Timing</u>

1. Sense Switch 3 ON - Load program, load data, and execute $\approx$ 1.4 min/frame
2. Sense Switch 3 OFF - Load program, load data, and execute $\approx$ 1.04 min/frame

FR	LOWER "A" X	LOWER "A" HEIGHT	LOWER "A" H.B.	SEQ	STRINGER #2 X	STRINGER #2 HEIGHT	STRINGER #2 H.B.	SEQ	LOWER "B" X	LOWER "B" HEIGHT	LOWER "B" H.B.	SEQ
116A	.0 00 0	.0 02 .1	.2 00 0	021	.0 00 0	.0 20 -.1	.5 06 0	011	.0 00 0	.0 90 0	.9 42 .1	001
B	.2 00 0	.0 02 .1	.2 00 0	022	.2 00 0	.0 20 0	.5 06 0	012	.2 00 0	.0 91 -.1	.9 42 0	002
C	.4 00 0	.0 02 .1	.2 00 0	023	.4 00 0	.0 21 -.1	.5 06 -.1	013	.4 00 0	.0 92 -.1	.9 42 0	003
D	.6 00 0	.0 02 .1	.2 00 0	024	.6 00 0	.0 22 .1	.5 05 .1	014	.6 00 0	.0 92 .1	.9 42 0	004
E	.8 00 0	.0 02 .1	.2 00 0	025	.8 00 0	.0 23 0	.5 05 .1	015	.8 00 0	.0 93 .1	.9 42 0	005
F	.10 00 0	.0 02 .1	.2 00 0	026	.10 00 0	.0 24 .1	.5 05 0	016	.10 00 0	.0 94 .1	.9 42 -.1	006
116	.12 00 0	.0 02 .1	.2 00 0	027	.12 00 0	.0 25 .1	.5 05 0	017	.12 00 0	.0 96 0	.9 41 .1	007
117	.14 00 0	.0 03 -.1	.2 00 0	028	.14 00 0	.0 27 -.1	.5 05 0	018	.14 00 0	.0 97 .1	.9 41 0	008
118	16 00 0	.0 03 0	.2 00 -.1	029	.16 00 0	.0 30 0	.5 05 -.1	019	.16 00 0	.0 101 0	.9 41 0	009
119	18 00 0	.0 03 .1	.2 00 -.1	030	18 00 0	.0 32 -.1	.5 04 .1	020	18 00 0	.0 103 0	.9 41 0	010

Fig. G-3 Sample Problem - The Set of Input Data for the Shell Plate to be Developed

Section VIII

SAMPLE PROBLEM

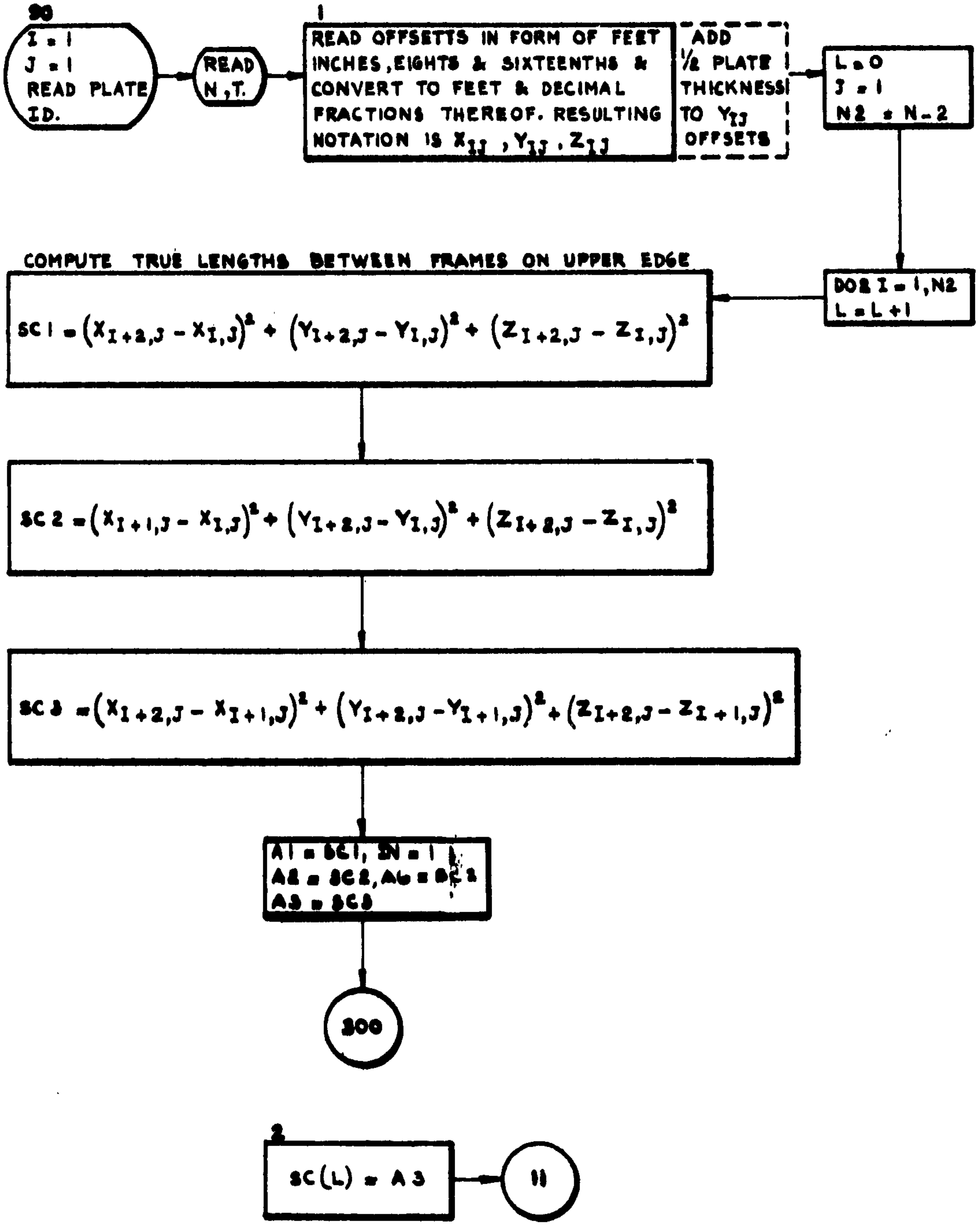
Figure G-3 shows a set of input data for a shell plate to be developed. The form on which this data is recorded was developed for use by the manual loft. Below is the listing of the coordinates of the pattern developed which was typed as the program was executed.

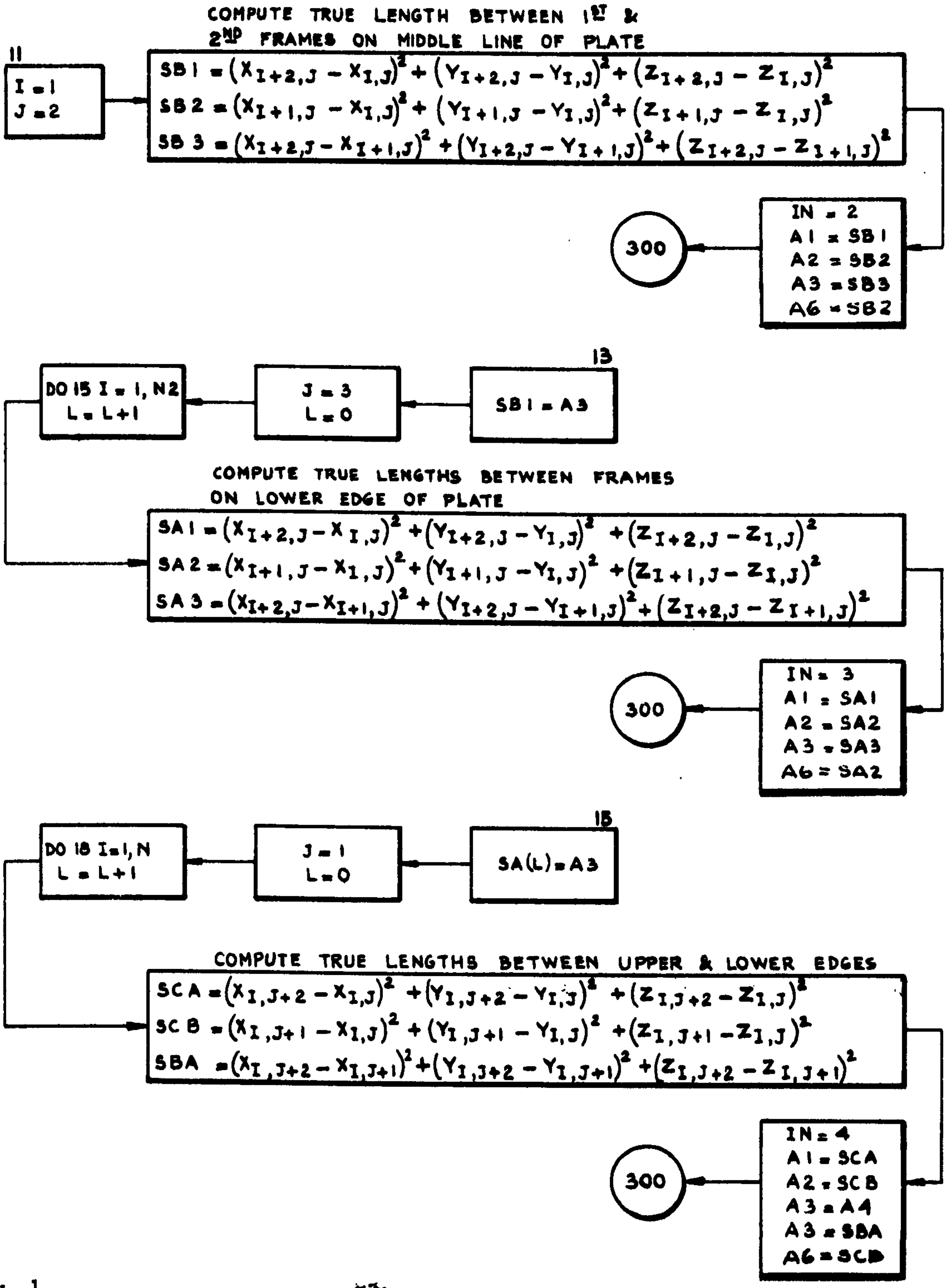
<u>Output (From computer typewriter)</u>

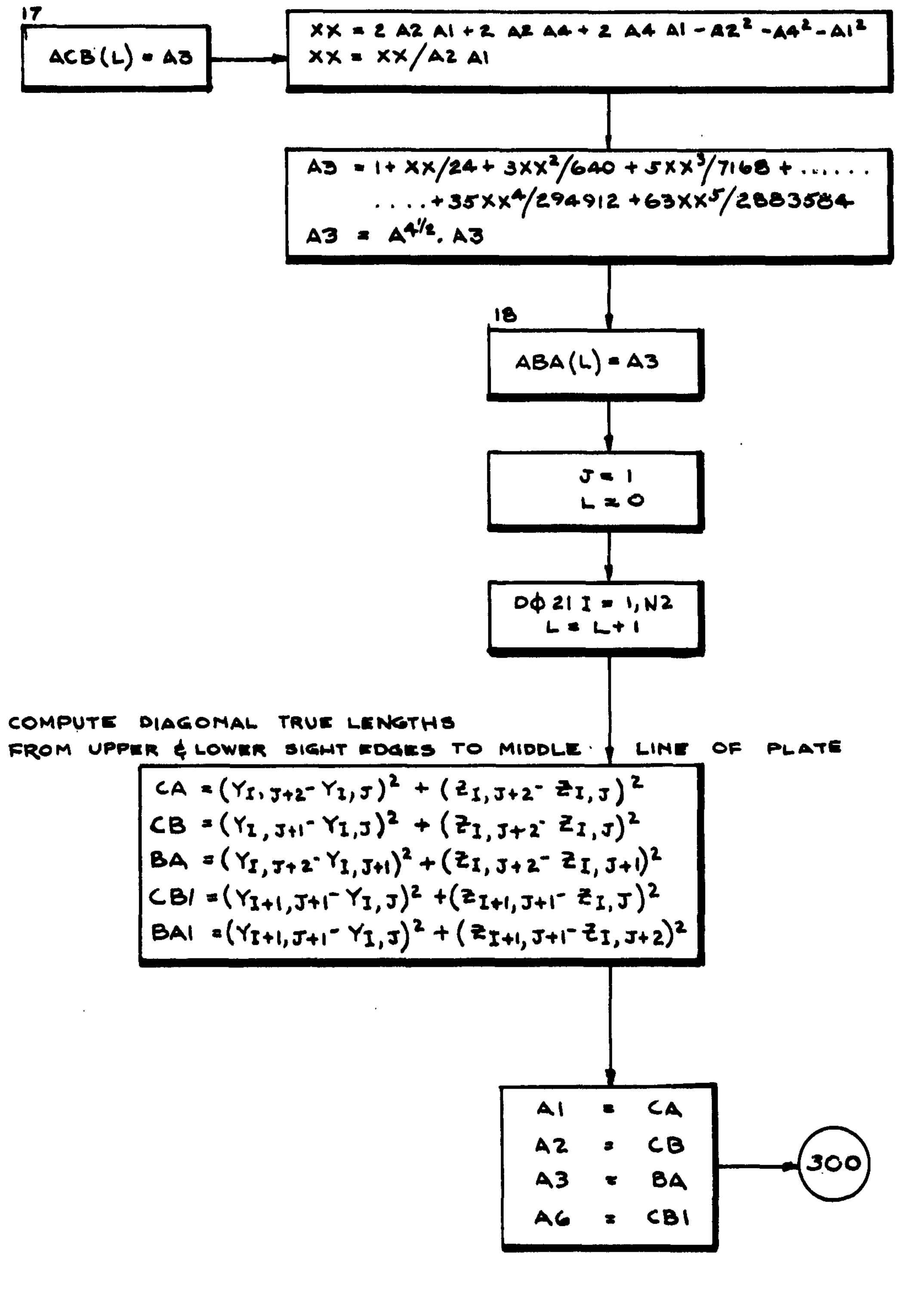
Listing of the coordinates of the pattern developed

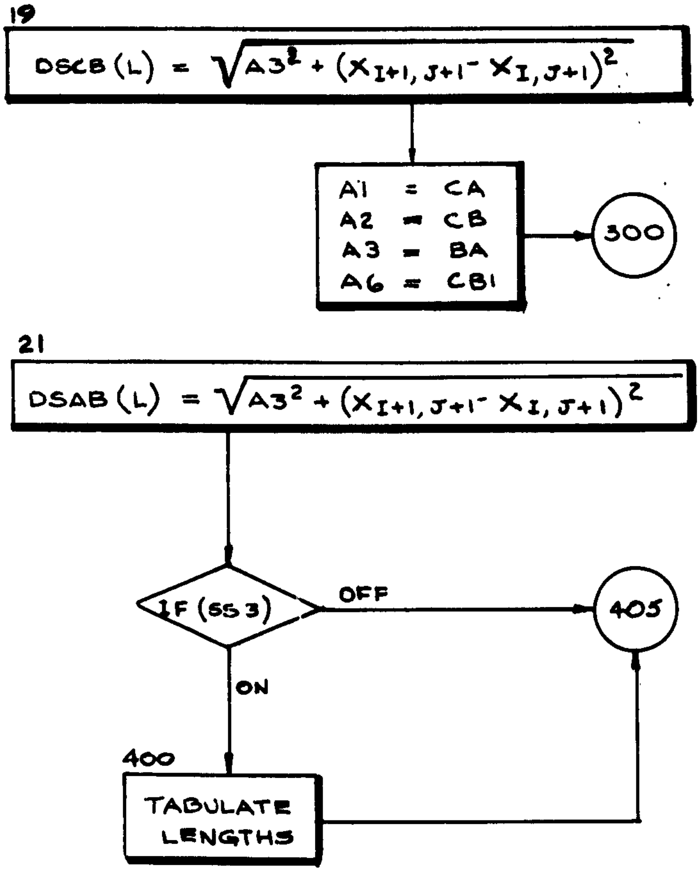
```
A- 10A
 XU(  1)=     .0018YU(  1)=     5.2069 FR 116 A
 XU(  2)=    2.4018YU(  2)=     5.2006 FR 116 B
 XU(  3)=    4.8018YU(  3)=     5.2014 FR 116 C
 XU(  4)=    7.2019YU(  4)=     5.2011 FR 116 D
 XU(  5)=    9.6019YU(  5)=     5.2019 FR 116 E
 XU(  6)=   12.0019YU(  6)=     5.1958 FR 116 F
 XU(  7)=   14.4020YU(  7)=     5.1972 FR 116
 XU(  8)=   16.8021YU(  8)=     5.1924 FR 117
 XU(  9)=   19.2022YU(  9)=     5.1936 FR 118
 XL(  1)=-    .0004YL(  1)=-    3.6794 FR 116 A
 XL(  2)=    2.3995YL(  2)=-    3.6797 FR 116 B
 XL(  3)=    4.7995YL(  3)=-    3.6799 FR 116 C
 XL(  4)=    7.1995YL(  4)=-    3.6792 FR 116 D
 XL(  5)=    9.5995YL(  5)=-    3.6795 FR 116 E
 XL(  6)=   11.9995YL(  6)=-    3.6792 FR 116 F
 XL(  7)=   14.3995YL(  7)=-    3.6793 FR 116
 XL(  8)=   16.7995YL(  8)=-    3.6795 FR 117
 XL(  9)=   19.1995YL(  9)=-    3.6852 FR 118
```

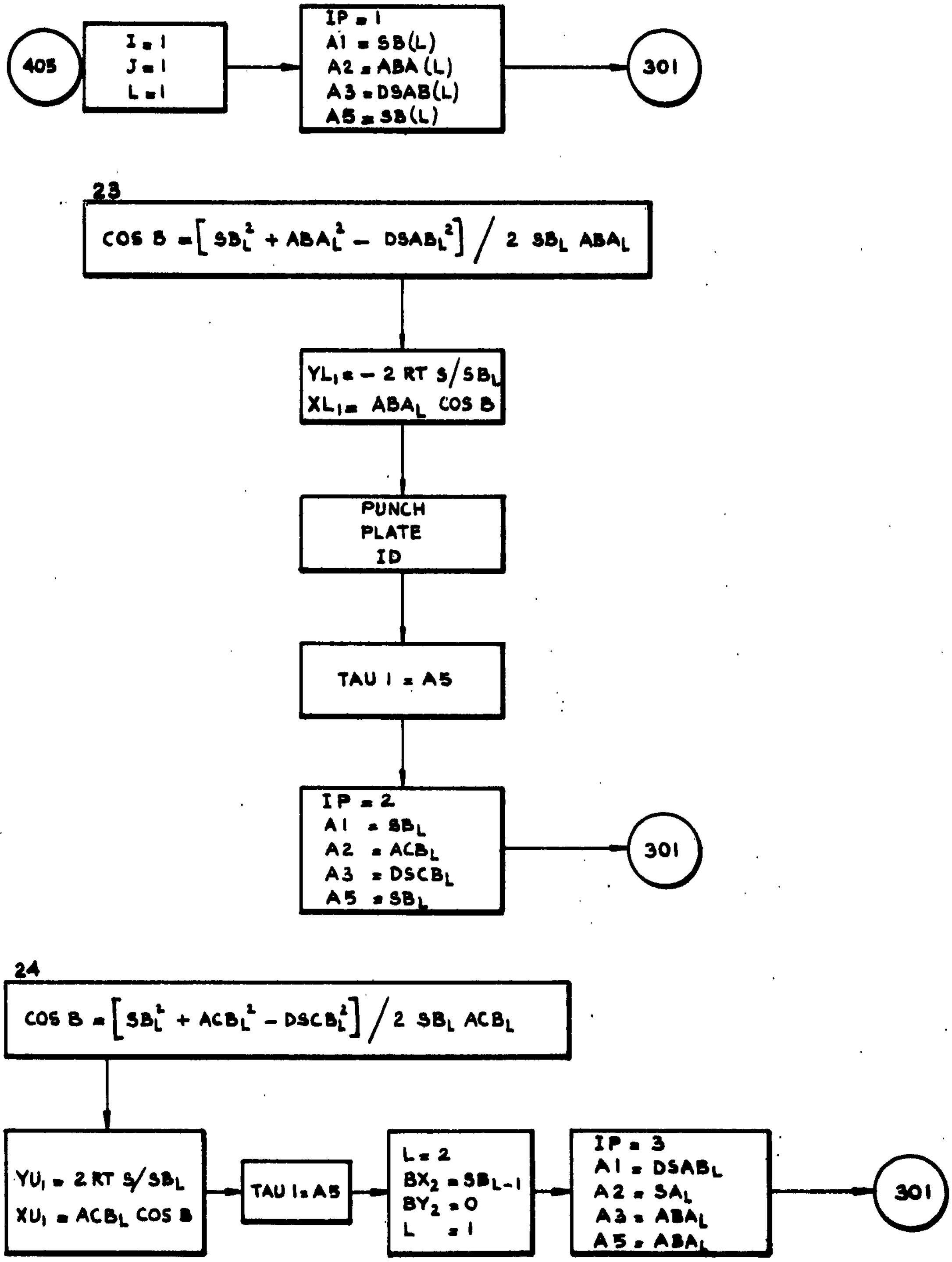
FLOW DIAGRAM

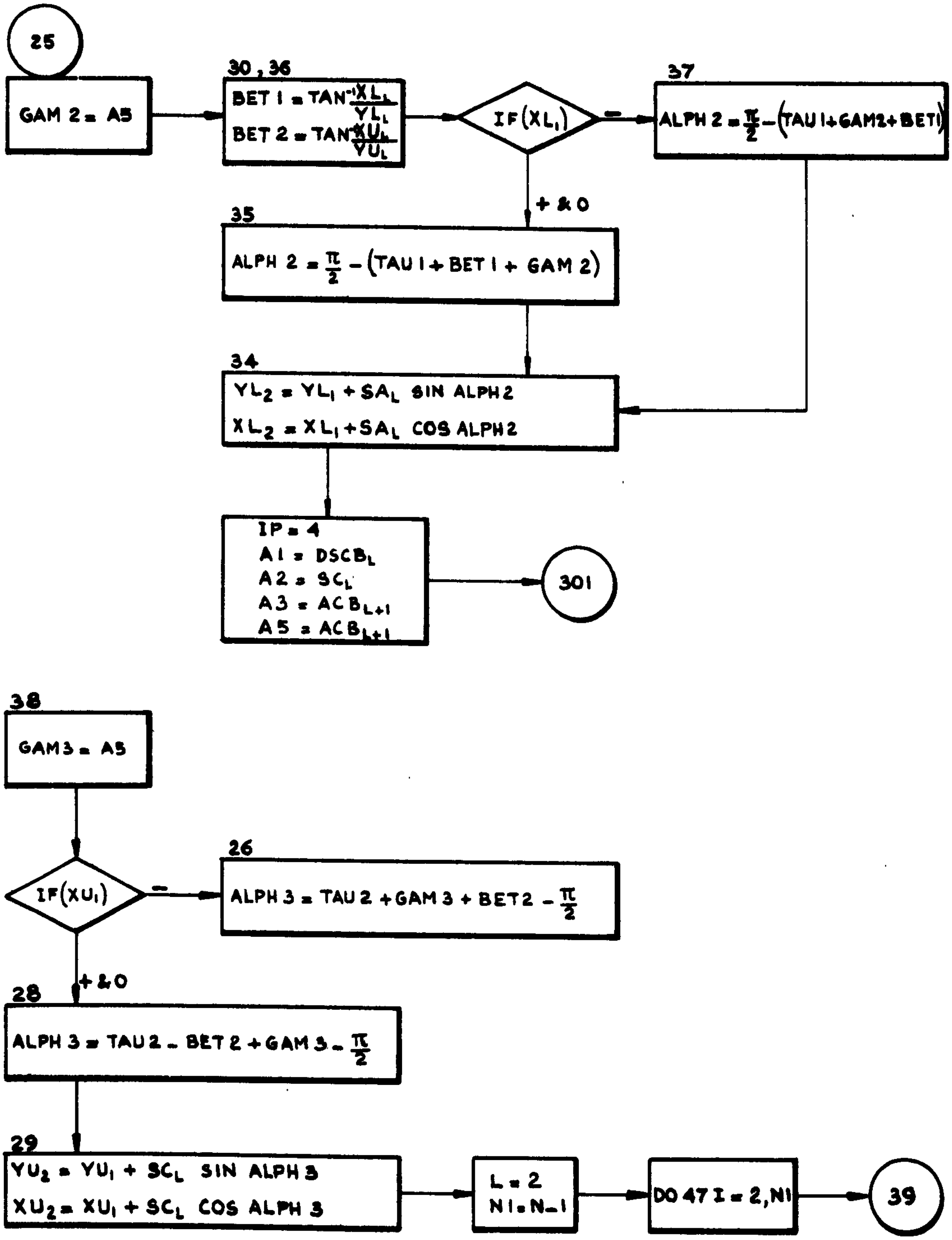


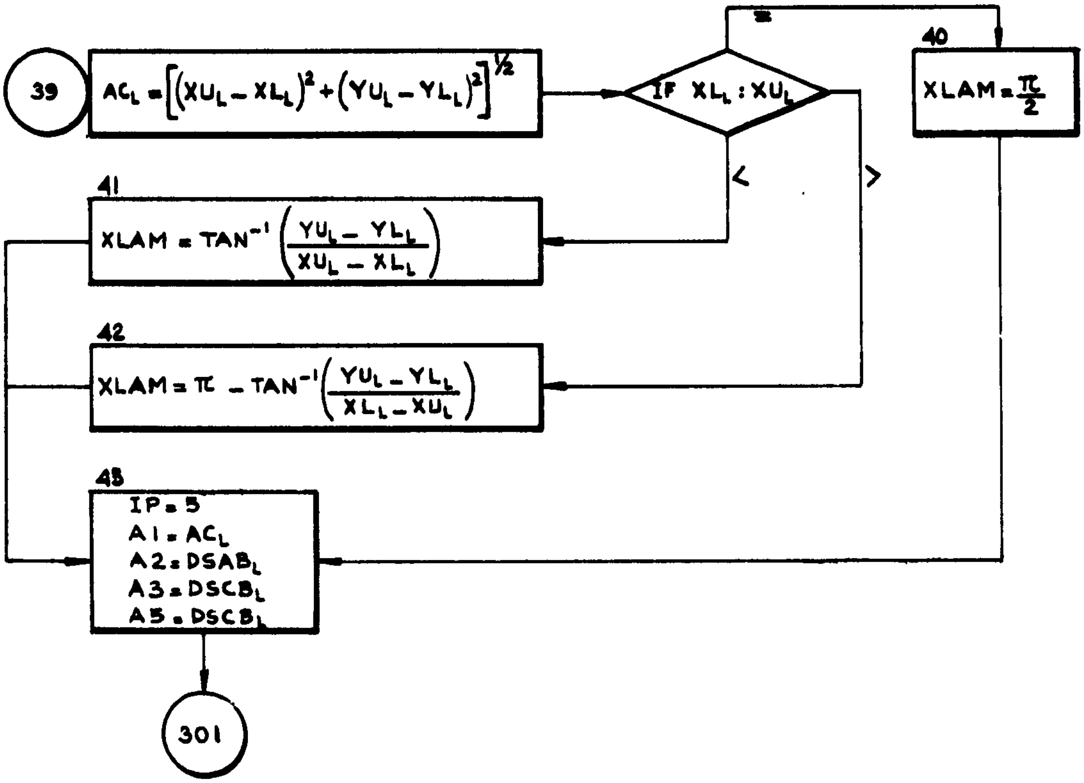

11
I = 1
J = 2
COMPUTE TRUE LENGTH BETWEEN 1ST & 2ND FRAMES ON MIDDLE LINE OF PLATE
$SB1 = (X_{I+2,J} - X_{I,J})^2 + (Y_{I+2,J} - Y_{I,J})^2 + (Z_{I+2,J} - Z_{I,J})^2$
$SB2 = (X_{I+1,J} - X_{I,J})^2 + (Y_{I+1,J} - Y_{I,J})^2 + (Z_{I+1,J} - Z_{I,J})^2$
$SB3 = (X_{I+2,J} - X_{I+1,J})^2 + (Y_{I+2,J} - Y_{I+1,J})^2 + (Z_{I+2,J} - Z_{I+1,J})^2$
IN = 2
A1 = SB1
A2 = SB2
A3 = SB3
A6 = SB2
300
13
SB1 = A3
J = 3
L = 0
DO 15 I = 1, N2
L = L+1
COMPUTE TRUE LENGTHS BETWEEN FRAMES ON LOWER EDGE OF PLATE
$SA1 = (X_{I+2,J} - X_{I,J})^2 + (Y_{I+2,J} - Y_{I,J})^2 + (Z_{I+2,J} - Z_{I,J})^2$
$SA2 = (X_{I+1,J} - X_{I,J})^2 + (Y_{I+1,J} - Y_{I,J})^2 + (Z_{I+1,J} - Z_{I,J})^2$
$SA3 = (X_{I+2,J} - X_{I+1,J})^2 + (Y_{I+2,J} - Y_{I+1,J})^2 + (Z_{I+2,J} - Z_{I+1,J})^2$
IN = 3
A1 = SA1
A2 = SA2
A3 = SA3
A6 = SA2
300
15
SA(L) = A3
J = 1
L = 0
DO 18 I = 1, N
L = L+1
COMPUTE TRUE LENGTHS BETWEEN UPPER & LOWER EDGES
$SCA = (X_{I,J+2} - X_{I,J})^2 + (Y_{I,J+2} - Y_{I,J})^2 + (Z_{I,J+2} - Z_{I,J})^2$
$SCB = (X_{I,J+1} - X_{I,J})^2 + (Y_{I,J+1} - Y_{I,J})^2 + (Z_{I,J+1} - Z_{I,J})^2$
$SBA = (X_{I,J+2} - X_{I,J+1})^2 + (Y_{I,J+2} - Y_{I,J+1})^2 + (Z_{I,J+2} - Z_{I,J+1})^2$
IN = 4
A1 = SCA
A2 = SCB
A3 = A4
A3 = SBA
A6 = SCB
300

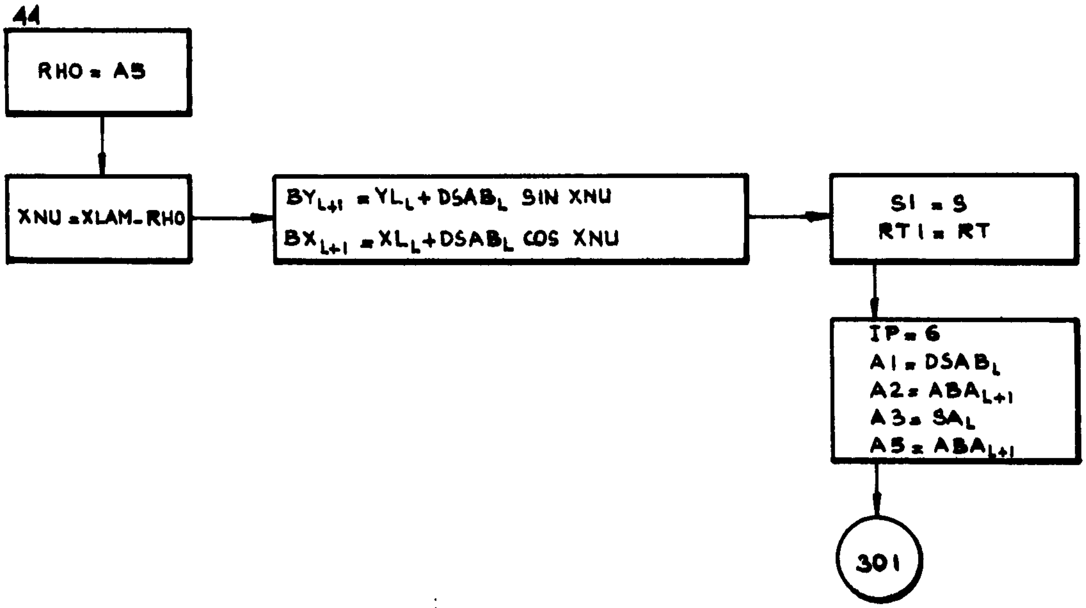

17
ACB(L) = A3
XX = 2 A2 A1 + 2 A2 A4 + 2 A4 A1 - A2² - A4² - A1²
XX = XX/A2 A1
A3 = 1+ XX/24 + 3XX²/640 + 5XX³/7168 + ...
.....+35XX⁴/294912 +63XX⁵/2883584
A3 = A4^1/2 . A3
18
ABA(L) = A3
J = 1
L = 0
DΦ 21 I = 1,N2
L = L+1
COMPUTE DIAGONAL TRUE LENGTHS
FROM UPPER & LOWER SIGHT EDGES TO MIDDLE LINE OF PLATE
CA = (Y I,J+2 - Y I,J)² + (Z I,J+2 - Z I,J)²
CB = (Y I,J+1 - Y I,J)² + (Z I,J+2 - Z I,J)²
BA = (Y I,J+2 - Y I,J+1)² + (Z I,J+2 - Z I,J+1)²
CB1 = (Y I+1,J+1 - Y I,J)² + (Z I+1,J+1 - Z I,J)²
BA1 = (Y I+1,J+1 - Y I,J)² + (Z I+1,J+1 - Z I,J+2)²
A1 = CA
A2 = CB
A3 = BA
A6 = CB1
300

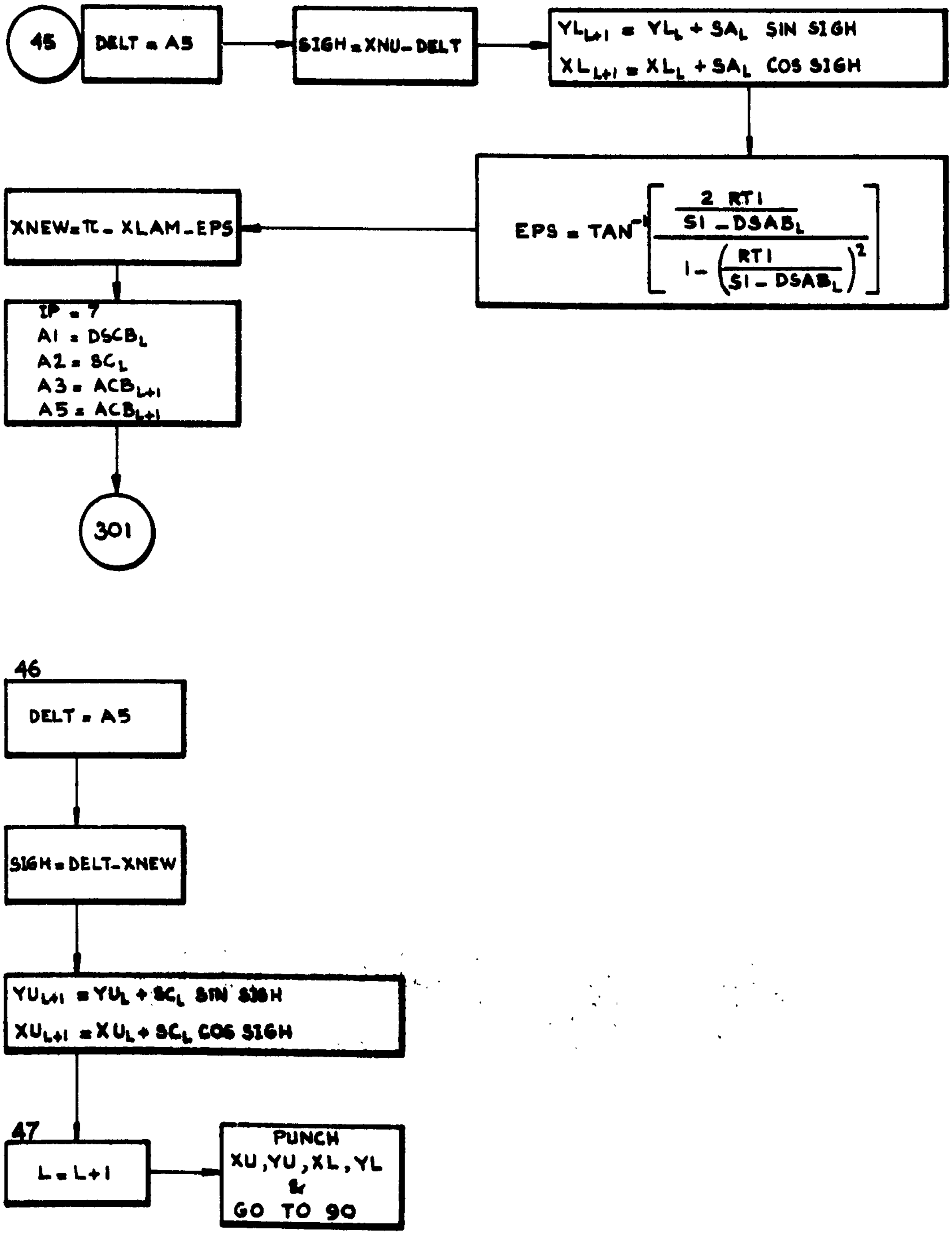

19
$DSCB(L) = \sqrt{A3^2 + (X_{I+1,J+1} - X_{I,J+1})^2}$
A1 = CA
A2 = CB
A3 = BA
A6 = CB1
300
21
$DSAB(L) = \sqrt{A3^2 + (X_{I+1,J+1} - X_{I,J+1})^2}$
IF (SS3)
OFF
405
ON
400
TABULATE LENGTHS


405
I = 1
J = 1
L = 1
IP = 1
A1 = SB(L)
A2 = ABA (L)
A3 = DSAB(L)
A5 = SB(L)
301
23
COS B = [SB_L^2 + ABA_L^2 − DSAB_L^2] / 2 SB_L ABA_L
YL_1 = − 2 RT S/SB_L
XL_1 = ABA_L COS B
PUNCH
PLATE
ID
TAU 1 = A5
IP = 2
A1 = SB_L
A2 = ACB_L
A3 = DSCB_L
A5 = SB_L
301
24
COS B = [SB_L^2 + ACB_L^2 − DSCB_L^2] / 2 SB_L ACB_L
YU_1 = 2 RT S/SB_L
XU_1 = ACB_L COS B
TAU 1 = A5
L = 2
BX_2 = SB_{L-1}
BY_2 = 0
L = 1
IP = 3
A1 = DSAB_L
A2 = SA_L
A3 = ABA_L
A5 = ABA_L
301


25
GAM 2 = A5
30, 36
BET 1 = TAN⁻¹ XL_L / YL_L
BET 2 = TAN⁻¹ XU_L / YU_L
IF (XL_1)
–
37
ALPH 2 = π/2 – (TAU 1 + GAM 2 + BET 1)
+ & 0
35
ALPH 2 = π/2 – (TAU 1 + BET 1 + GAM 2)
34
YL_2 = YL_1 + SA_L SIN ALPH 2
XL_2 = XL_1 + SA_L COS ALPH 2
IP = 4
A1 = DSCB_L
A2 = SC_L
A3 = ACB_L+1
A5 = ACB_L+1
301
38
GAM 3 = A5
IF (XU_1)
–
26
ALPH 3 = TAU 2 + GAM 3 + BET 2 – π/2
+ & 0
28
ALPH 3 = TAU 2 – BET 2 + GAM 3 – π/2
29
YU_2 = YU_1 + SC_L SIN ALPH 3
XU_2 = XU_1 + SC_L COS ALPH 3
L = 2
N1 = N – 1
DO 47 I = 2, N1
39


39
ACL = [(XUL − XLL)² + (YUL − YLL)²]^½
IF XLL : XUL
=
<
>
40
XLAM = π/2
41
XLAM = TAN⁻¹ ((YUL − YLL)/(XUL − XLL))
42
XLAM = π − TAN⁻¹ ((YUL − YLL)/(XLL − XUL))
43
IP = 5
A1 = ACL
A2 = DSABL
A3 = DSCBL
A5 = DSCBL
301


44
RHO = A5
XNU = XLAM − RHO
BYL+1 = YLL + DSABL SIN XNU
BXL+1 = XLL + DSABL COS XNU
S1 = S
RT1 = RT
IP = 6
A1 = DSABL
A2 = ABAL+1
A3 = SAL
A5 = ABAL+1
301


45
DELT = A5
SIGH = XNU − DELT
$YL_{L+1} = YL_L + SA_L \sin SIGH$
$XL_{L+1} = XL_L + SA_L \cos SIGH$
$EPS = TAN^{-1}\left[\dfrac{\dfrac{2\ RT1}{S1 - DSAB_L}}{1 - \left(\dfrac{RT1}{S1 - DSAB_L}\right)^2}\right]$
XNEW = π − XLAM − EPS
IP = 7
$A1 = DSCB_L$
$A2 = SC_L$
$A3 = ACB_{L+1}$
$A5 = ACB_{L+1}$
301
46
DELT = A5
SIGH = DELT − XNEW
$YU_{L+1} = YU_L + SC_L \sin SIGH$
$XU_{L+1} = XU_L + SC_L \cos SIGH$
47
L = L+1
PUNCH
XU, YU, XL, YL
&
GO TO 90

300

$$XX = 2\,A2\,A1 + 2\,A2\,A3 + 2\,A3\,A1 - A2^2 - A3^2 - A1^2$$

$$XX = (XX\,A6)/(A3\,A2\,A1)$$

$$A3 = 1 + XX/24 + 3XX^2/640 + 5XX^3/7168 + \ldots$$
$$\ldots + 35XX^4/294912 + 63XX^5/2883584$$

$$A3 = A3\sqrt{A6}$$

COMPUTED
GO TO IN =
2, 13, 15, 17, 19, 21

301

$$S = (A1 + A2 + A3)/2$$

$$RT = \sqrt{\frac{1}{S}(S-A1)(S-A2)(S-A3)}$$

$$A5 = TAN^{-1}\left[\frac{\dfrac{2\,RT}{S-A5}}{1-\left(\dfrac{RT}{S-A5}\right)^2}\right]$$

COMPUTED
GO TO IP =
23,24,25,38,44,45,46

FORTRAN PROGRAM LISTING

```
      DIMENSION X( 53,3),Y( 53,3),Z( 53,3),SC( 51),SA( 51),ACB( 53)
      DIMENSION DSCB( 51),DSAB( 51)
      DIMENSION BX( 53),BY( 53),ABA( 53),SB(2),AC( 53)
      DIMENSION XL(53),XU(53),YU(53),YL(53)
   90 READ 108,ID
      READ 100,N,T
      DO 9 J=1,3
      DO 3 I=1,N
    1 READ101,IXF,IXI,IXE,IXS,IZF,IZI,IZE,IZS,IYF,IYI,IYE,IYS
      XF=IXF
      XI=IXI
      XE=IXE
      XS=IXS
      YF=IYF
      YI=IYI
      YE=IYE
      YS=IYS
      ZF=IZF
      ZI=IZI
      ZE=IZE
      ZS=IZS
      X(I,J)=XF+(XI/12.)+(XE/96.)+(XS/192.)
      Y(I,J)=YF+(YI/12.)+(YE/96.)+(YS/192.)+(T/24.)
    3 Z(I,J)=ZF+(ZI/12.)+(ZE/96.)+(ZS/192.)
    9 CONTINUE
      I=1
      J=1
      L=0
      N2=N-2
      DO 2 I=1,N2
    8 L=L+1
      SC1=(X(I+2,J)-X(I,J))*(X(I+2,J)-X(I,J))
      SC1=SC1+(Y(I+2,J)-Y(I,J))*(Y(I+2,J)-Y(I,J))
      SC1=     (SC1+(Z(I+2,J)-Z(I,J))*(Z(I+2,J)-Z(I,J)))
      SC2=(X(I+1,J)-X(I,J))*(X(I+1,J)-X(I,J))
      SC2=SC2+(Y(I+1,J)-Y(I,J))*(Y(I+1,J)-Y(I,J))
     SC2=      SC2+(Z(I+1,J)-Z(I,J))*(Z(I+1,J)-Z(I,J))
      SC3=(X(I+2,J)-X(I+1,J))*(X(I+2,J)-X(I+1,J))
      SC3=SC3+(Y(I+2,J)-Y(I+1,J))*(Y(I+2,J)-Y(I+1,J))
      SC3=     (SC3+(Z(I+2,J)-Z(I+1,J))*(Z(I+2,J)-Z(I+1,J)))
      IN=1
      A1=SC1
      A2=SC2
      A3=SC3
      A6=SC2
      GO TO  300
    2 SC(L)=A3
      L=1
```

```
11 I=1
   J=2
12 SB1=(X(I+2,J)-X(I,J))*(X(I+2,J)-X(I,J))
   SB1=SB1+(Y(I+2,J)-Y(I,J))*(Y(I+2,J)-Y(I,J))
   SB1=      (SB1+(Z(I+2,J)-Z(I,J))*(Z(I+2,J)-Z(I,J)))
   SB2=(X(I+1,J)-X(I,J))*(X(I+1,J)-X(I,J))
   SB2=SB2+(Y(I+1,J)-Y(I,J))*(Y(I+1,J)-Y(I,J))
   SB2=      (SB2+(Z(I+1,J)-Z(I,J))*(Z(I+1,J)-Z(I,J)))
   SB3=(X(I+2,J)-X(I+1,J))*(X(I+2,J)-X(I+1,J))
   SB3=SB3+(Y(I+2,J)-Y(I+1,J))*(Y(I+2,J)-Y(I+1,J))
   SB3=      (SB3+(Z(I+2,J)-Z(I+1,J))*(Z(I+2,J)-Z(I+1,J)))
   A1=SB1
   A2=SB2
   A3=SB3
   IN=2
   A6=SB2
   GO TO  300
13 SB(L)=A3
   J=3
   I=1
   L=0
   DO15 I=1,N2
14 L=L+1
   SA1=(X(I+2,J)-X(I,J))*(X(I+2,J)-X(I,J))
   SA1=SA1+(Y(I+2,J)-Y(I,J))*(Y(I+2,J)-Y(I,J))
   SA1=      (SA1+(Z(I+2,J)-Z(I,J))*(Z(I+2,J)-Z(I,J)))
   SA2=(X(I+1,J)-X(I,J))*(X(I+1,J)-X(I,J))
   SA2=SA2+(Y(I+1,J)-Y(I,J))*(Y(I+1,J)-Y(I,J))
   SA2=      (SA2+(Z(I+1,J)-Z(I,J))*(Z(I+1,J)-Z(I,J)))
   SA3=(X(I+2,J)-X(I+1,J))*(X(I+2,J)-X(I+1,J))
   SA3=SA3+(Y(I+2,J)-Y(I+1,J))*(Y(I+2,J)-Y(I+1,J))
   SA3=      (SA3+(Z(I+2,J)-Z(I+1,J))*(Z(I+2,J)-Z(I+1,J)))
   A1=SA1
   A2=SA2
   A3=SA3
   A6=SA2
   IN=3
   GO TO  300
15 SA(L)=A3
   I=1
   J=1
   L=0
   DO 18 I=1,N
   L=L+1
   SCA=(X(I,J+2)-X(I,J))*(X(I,J+2)-X(I,J))
   SCA=SCA+(Y(I,J+2)-Y(I,J))*(Y(I,J+2)-Y(I,J))
   SCA=      (SCA+(Z(I,J+2)-Z(I,J))*(Z(I,J+2)-Z(I,J)))
```

```
      SCB=(X(I,J+1)-X(I,J))*(X(I,J+1)-X(I,J))
      SCB=SCB+(Y(I,J+1)-Y(I,J))*(Y(I,J+1)-Y(I,J))
      SCB=     (SCB+(Z(I,J+1)-Z(I,J))*(Z(I,J+1)-Z(I,J)))
      SBA=(X(I,J+2)-X(I,J+1))*(X(I,J+2)-X(I,J+1))
      SBA=SBA+(Y(I,J+2)-Y(I,J+1))*(Y(I,J+2)-Y(I,J+1))
      SBA=     (SBA+(Z(I,J+2)-Z(I,J+1))*(Z(I,J+2)-Z(I,J+1)))
      A1=SCA
      A2=SCB
      A3=SBA
      A6=SCB
      IN=4
      GO TO  300
   17 ACB(L)=A3
      XX=2.*A2*A1+2.*A2*A4+2.*A4*A1-A2*A2-A4*A4-A1*A1
      XX=XX/(A2*A1)
      IF(XX-1.)905,905,906
  906 TYPE 115
  905 A3=1.+XX/24.+3.*XX*XX/640.+5.*XX*XX*XX/7168.
      A3=A3+35.*XX**4/294912.+63.*XX**5/2883584.
      A3=SQRTF(A4)*A3
   18 ABA(L)=A3
      I=1
      J=1
      L=0
      DO 21  I=1,N2
      L=L+1
      CA=(Y(I,J+2)-Y(I,J))*(Y(I,J+2)-Y(I,J))
      CA=CA+(Z(I,J+2)-Z(I,J))*(Z(I,J+2)-Z(I,J))
      CB=(Y(I,J+1)-Y(I,J))*(Y(I,J+1)-Y(I,J))
      CB=CB+(Z(I,J+1)-Z(I,J))*(Z(I,J+1)-Z(I,J))
      BA=(Y(I,J+2)-Y(I,J+1))*(Y(I,J+2)-Y(I,J+1))
      BA=BA+(Z(I,J+2)-Z(I,J+1))*(Z(I,J+2)-Z(I,J+1))
      CB1=(Y(I+1,J+1)-Y(I,J))*(Y(I+1,J+1)-Y(I,J))
      CB1=CB1+(Z(I+1,J+1)-Z(I,J))*(Z(I+1,J+1)-Z(I,J))
      BA1=(Y(I+1,J+1)-Y(I,J+2))*(Y(I+1,J+1)-Y(I,J+2))
      BA1=BA1+(Z(I+1,J+1)-Z(I,J+2))*(Z(I+1,J+1)-Z(I,J+2))
      A1=CA
      A2=CB
      A3=BA
      A6=CB1
      IN=5
      GOTO 300
   19 DSCB(L)=SQRTF(A3*A3+(X(I+1,J+1)-X(I,J+1))*(X(I+1,J+1)-X(I,J+1)))
      A1=CA
      A2=CB
      A3=BA
      A6=BA1
```

```
      IN=6
      GO TO 300
   21 DSAB(L)=SQRTF(A3*A3+(X(I+1,J+1)-X(I,J+1))*(X(I+1,J+1)-X(I,J+1))
     )
      IF(SENSE SWITCH 3)400,405
  400 N8=N-2
      L=0
      DO 401 I=1,N8
      L=L+1
  401 TYPE 105 ,L,SC(I),L,SA(I)
      L=0
      N1=N-1
      DO 402 I=1,N1
      L=L+1
  402 TYPE 106 ,L,ACB(I),L,ABA(I)
      L=0
      DO 403 I=1,N8
      L=L+1
  403 TYPE 107 ,L,DSCB(I),L,DSAB(I)
  405 I=1
      J=1
      L=1
      A1=SB(L)
      A2=ABA(L)
      A3=DSAB(L)
      IP=1
      A5=SB(L)
      GO TO  301
   23 COSB=((SB(L))**2+(ABA(L))**2-(DSAB(L))**2)/(2.*SB(L)*ABA(L))
      YL(L)=(-2.*RT*S)/SB(L)
      XL(L)=ABA(L)*COSB
      PUNCH 108,ID
      TAU1=A5
      A1=SB(L)
      A2=ACB(L)
      A3=DSCB(L)
      IP=2
      A5=SB(L)
      GO TO  301
   24 COSB=((SB(L))**2+(ACB(L))**2-(DSCB(L))**2)/(2.*SB(L)*ACB(L))
      YU(L)=(2.*RT*S)/SB(L)
      XU(L)=ACB(L)*COSB
      TAU2=A5
      L=2
      BX(L)=SB(L-1)
      BY(L)=0.0
      L=1
      A1=DSAB(L)
```

```
      A2=SA(L)
      A3=ABA(L+1)
      IP=3
      A5=ABA(L+1)
      GO TO  301
   25 GAM2=A5
   30 BET1=XL(L)/YL(L)
      BET1=ATANF(ABSF(BET1))
   36 BET2=XU(L)/YU(L)
      BET2=ATANF(ABSF(BET2))
      IF(XL(L))37,35,35
   37 ALPH2=1.5708-(TAU1+GAM2+BET1)
      GO TO 34
   35 ALPH2=1.5708-(TAU1-BET1+GAM2)
   34 YL(L+1)=YL(L)+(SA(L)*SINF(ALPH2))
      XL(L+1)=XL(L)+(SA(L)*COSF(ALPH2))
      L=1
      A1=DSCB(L)
      A2=SC(L)
      A3=ACB(L+1)
      IP=4
      A5=ACB(L+1)
      GO TO  301
   38 GAM3=A5
      IF(XU(L))26,28,28
   26 ALPH3=TAU2+GAM3+BET2-1.5708
      GO TO 29
   28 ALPH3=TAU2-BET2+GAM3-1.5708
   29 YU(L+1)=YU(L)+(SC(L)*SINF(ALPH3))
      XU(L+1)=XU(L)+(SC(L)*COSF(ALPH3))
      L=2
      N1=N-1
      DO47 I=2,N1
   39 AC(L)=((XU(L)-XL(L))*(XU(L)-XL(L)))+((YU(L)-YL(L))*(YU(L)-YL(L)
 ))
      AC(L)=SQRTF(ABSF(AC(L)))
      IF(XL(L)-XU(L))41,40,42
   40 XLAM=1.5708
      GO TO  43
   41 XLAM=ATANF((YU(L)-YL(L))/(XU(L)-XL(L)))
      GO TO 43
   42 XLAM=3.1416-ATANF((YU(L)-YL(L))/(XL(L)-XU(L)))
   43 A1=AC(L)
      A2=DSAB(L)
      A3=DSCB(L)
      IP=5
      A5=DSCB(L)
      GO TO  301
```

```
44 RHO=A5
   XNU=XLAM-RHO
   BY(L+1)=YL(L)+(DSAB(L)*SINF(XNU))
   BX(L+1)=XL(L)+(DSAB(L)*COSF(XNU))
   S1=S
   RT1=RT
   A1=DSAB(L)
   A2=ABA(L+1)
   A3=SA(L)
   IP=6
   A5=ABA(L+1)
   GO TO 301
45 DELT=A5
   SIGH=XNU-DELT
   YL(L+1)=YL(L)+(SA(L)*SINF(SIGH))
   XL(L+1)=XL(L)+(SA(L)*COSF(SIGH))
   EPS=ATANF(((2.*RT1)/(S1-DSAB(L)))/(1.-(RT1/(S1-DSAB(L)))**2))
   XNEW=3.1416-XLAM-EPS
   A1=DSCB(L)
   A2=SC(L)
   A3=ACB(L+1)
   IP=7
   A5=ACB(L+1)
   GO TO 301
46 DELT=A5
   SIGH=DELT-XNEW
   YU(L+1)=YU(L)+(SC(L)*SINF(SIGH))
   XU(L+1)=XU(L)+(SC(L)*COSF(SIGH))
47 L=L+1
   DO 48 L=1,N1
   XU(L)=XU(L)*1.2
   YU(L)=YU(L)*1.2
   IF(XU(L))51,52,52
51 XU(L)=ABSF(XU(L))
   IF(YU(L))54,58,58
54 YU(L)=ABSF(YU(L))
   PUNCH 110,L,XU(L),L,YU(L)
   GO TO 48
58 PUNCH 113,L,XU(L),L,YU(L)
   GO TO 48
52 IF(YU(L))55,56,56
55 YU(L)=ABSF(YU(L))
   PUNCH 114,L,XU(L),L,YU(L)
   GO TO 48
56 PUNCH 103,L,XU(L),L,YU(L)
48 CONTINUE
   DO 49 L=1,N1
   XL(L)=XL(L)*1.2
```

```
      YL(L)=YL(L)*1.2
      IF(XL(L))61,62,62
   61 XL(L)=ABSF(XL(L))
      IF(YL(L))64,68,68
   64 YL(L)=ABSF(YL(L))
      PUNCH 109,L,XL(L),L,YL(L)
      GO TO 49
   68 PUNCH 111,L,XL(L),L,YL(L)
      GO TO 49
   62 IF(YL(L))65,66,66
   65 YL(L)=ABSF(YL(L))
      PUNCH 112 ,L,XL(L),L,YL(L)
      GO TO 49
   66 PUNCH 102,L,XL(L),L,YL(L)
   49 CONTINUE
      GO TO  90
  300 A4=A3
      XX=2.*A2*A1+2.*A2*A3+2.*A3*A1-A2*A2-A3*A3-A1*A1
      XX=(XX*A6)/(A3*A2*A1)
      IF(XX-1.)900,900,901
  901 TYPE 115
  900 A3=1.+XX/24.+3.*XX*XX/640.+5.*XX*XX*XX/7168.
      A3=A3+35.*XX**4/294912.+63.*XX**5/2883584.
      A3=SQRTF(A6)*A3
      GO TO (2,13,15,17,19,21),IN
  301 S=(A1+A2+A3)/2.
      RT=SQRTF(ABSF(((S-A1)*(S-A2)*(S-A3))/S))
      A5=ATANF((2.*RT/(S-A5))/(1.-(RT/(S-A5))**2))
      GO TO(23,24,25,38,44,45,46),IP
  101 FORMAT(I3,I2,I1,I2,I3,I2,I1,I2,I3,I2,I1,I2)
  100 FORMAT(I3,F7.4)
  102 FORMAT(4H XL(,I3,2H)=,F10.4,3HYL(,I3,2H)=,F10.4)
  103 FORMAT(4H XU(,I3,2H)=,F10.4,3HYU(,I3,2H)=,F10.4)
  105 FORMAT(3HSC(,I3,2H)=,F9.4,4X,3HSA(,I3,2H)=,F9.4)
  106 FORMAT(4HACB(,I3,2H)=,F9.4,4X,4HABA(,I3,2H)=,F9.4)
  107 FORMAT(5HDSCB(,I3,2H)=,F9.4,4X,5HDSAB(,I3,2H)=,F9.4)
  108 FORMAT(2HA-,I3)
  109 FORMAT(4H XL(,I3,3H)=-,F9.4,3HYL(,I3,3H)=-,F9.4)
  110 FORMAT(4H XU(,I3,3H)=-,F9.4,3HYU(,I3,3H)=-,F9.4)
  111 FORMAT(4H XL(,I3,3H)=-,F9.4,3HYL(,I3,2H)=,F10.4)
  113 FORMAT(4H XU(,I3,3H)=-,F9.4,3HYU(,I3,2H)=,F10.4)
  112 FORMAT(4H XL(,I3,2H)=,F10.4,3HYL(,I3,3H)=-,F9.4)
  114 FORMAT(4H XU(,I3,2H)=,F10.4,3HYU(,I3,3H)=-,F9.4)
  115 FORMAT(20HS/R GREATER THAN ONE)
      END
```

Appendix H

CALCULATION OF OFFSETS FOR FRAME BENDING TEMPLATES

CONTENTS

Appendix H

CALCULATION OF OFFSETS FOR FRAME BENDING TEMPLATES

Bending templates for accurately determining the shape of frames for forming are one form of information required of any lofting system. Assuming an equation is at hand for the shape of the hull at a given frame, this program calculates the proper offsets for describing the frame bending template.

The program is written in FORTRAN II for the IBM-1620 computer. The method of solution, operating details, a sample problem, flow diagram, and program listing are included in this Appendix.

METHOD OF SOLUTION

The input information necessary to solve the problem consists of:

- The function that describes the shape of the hull, $Y = F(Z)$
- The end points of the frame segments, Z_1 and Z_2
- The step size between solution points, S
- The offset (V) which gives depth to the template, or allows for the width of the frame.

This problem is graphically presented in Fig. H-1. The solution is as follows:

GIVEN: $Y = f(Z)$, Z_1, Z_2, V, S

FIND: OFFSETS W_L at intervals S as shown in Fig. H-1

METHOD:

1. $Y_1 = f(Z)$ at Z_1

   $Y_2 = f(Z)$ at Z_2

2. $$M = \frac{Z_1 - Z_2}{Y_1 - Y_2}$$

3. $\gamma = \tan^{-1} |M|$

4. $H = S \sin \gamma$

   $R = S \cos \gamma$

   $F = V \sin \beta$

   $G = V \cos \beta$

5. $\beta = 90^\circ - \gamma$

6. $YA_1 = Y_1 - G$

7. $\delta = \frac{|M|}{M}$, δ assumes a value of +1 if the slope is positive, -1 if the slope is negative

8. $ZA_1 = Z_1 + \delta F$

   $Z\ END = Z_2 + \delta F$

9. The Coordinates of Points PA_1 and P_{end} have now been established. The offset at these points is, of course equal to V.

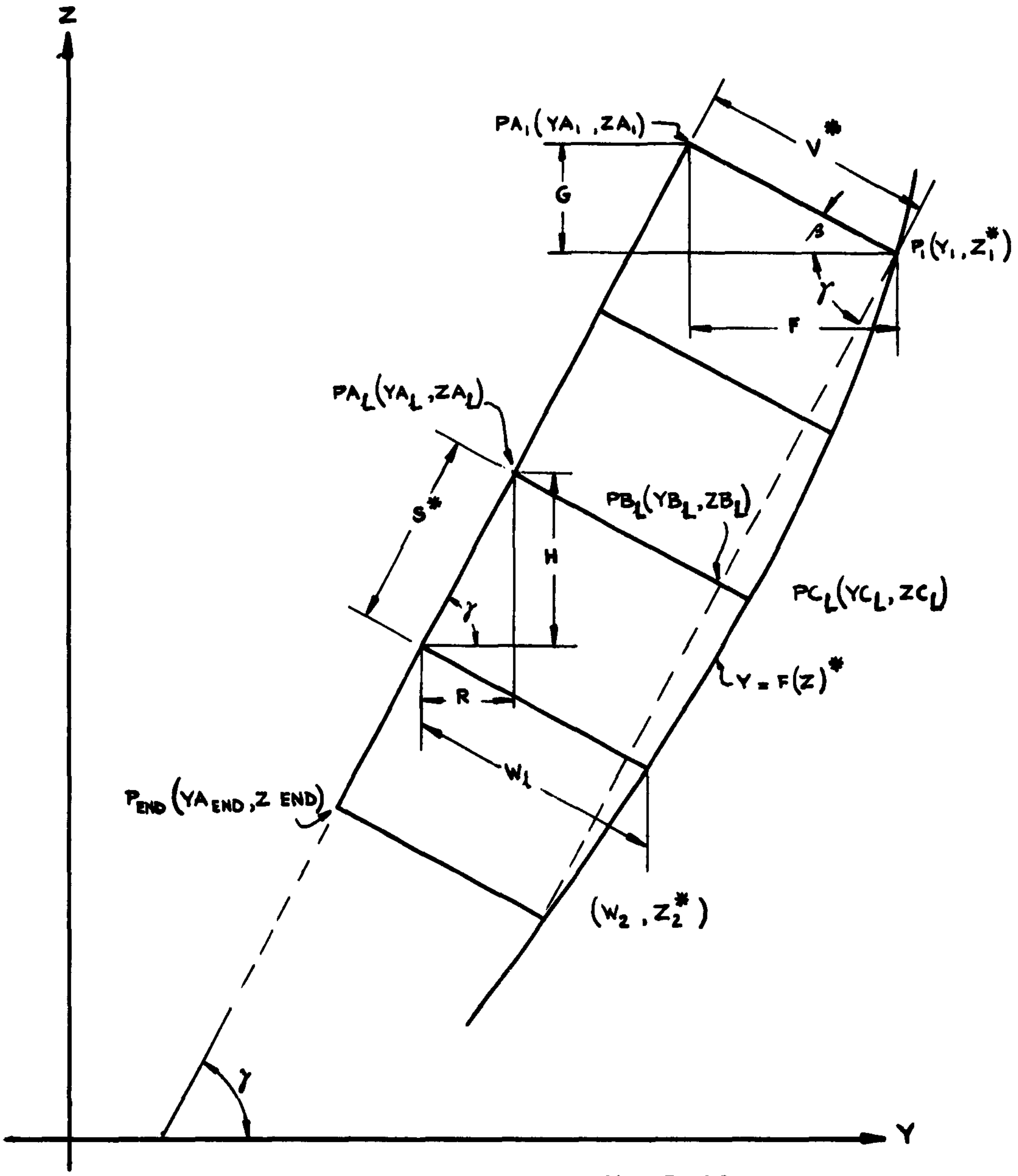


Fig. H-1 Geometry of Frame Bending Problem

* DENOTES GIVEN DATA

10. Step through the following for each required offset , W_L

$L = 1 , 2 , 3 , \ldots ,$ until $ZA_L \leq Z_{END} + H$

11. $ZA_L = ZA_{L-1} - H$

$ZB_L = ZB_{L-1} - H$

$YA_L = YA_{L-1} - \delta R$

$YB_L = YB_{L-1} - \delta R$

12. The solution for ZC_L involves a trial and error solution. Newton's Method was selected for this:

First:

$$YC_L = f(Z) \text{ evaluated at } ZC_L$$

(1) $$YC_L = AZC_L^3 + BZC_L^2 + CZC_L + D$$

Also:

(2) $$YC_L = YB_L - M(\delta)(ZC_L - ZB_L)$$

Subtracting (2) from (1) gives

(3) $$0 = AZC_L^3 + BZC_L^2 + CZC_L + D - \left[YB_L - M(\delta)(BC_L - ZB_L)\right]$$

ZC_L is the only unknown in (3) and may be solved for using Newton's Method.

13. $YC_L = f(Z)_{ZCL}$

14. $$W_L = \left[(YC_L - YA_L)^2 + (ZC_L - ZA_L)^2\right]^{\frac{1}{2}}$$

a. Input Data

A definition of the program input symbols and card formats are given below:

Input Symbols

A, B, C, D = Coefficients of a standard cubic equation describing the molded shape of the frame. The equation is of the form $AX^3 + BX^2 + CX + D$

IDSTA = Four digit integer frame identification

Z_1 = Upper limit of the frame segment to be analyzed

Z_2 = Lower limit of the frame segment to be analyzed

DIS = Minimum offset to allow for depth of frame (F in Fig. H-1)

S = Distance along chord of curve between required offsets.

First Card Format:

Variable	Format	Card Columns
A	4F15.8	1 - 15
B		16 - 30
C		31 - 45
D		46 - 60
DIS	2F7.3	61 - 67
S		68 - 74
IDSTA	I5	75 - 79

Last Card Format

Variable	Format	Card Columns
Z_1	2F10.5	1 - 10
Z_2		11 - 20

b. Output Data

The order of output is as follows:

1. The frame identification is typed

2. The coordinates of P_1 and P_2 (Fig. H-1) are typed

3. The coordinates of each successive point PA_L and the offset at that point are typed

Output Messages

If the slope of the chord of the frame segment equals zero, a message is typed and the angle γ is set to 90°

c. Switch Settings

Switch 1 - OFF, After completion of the calculations for a given problem, the program looks for an entire new set of data in the card reader.

Switch 1 - ON, After completion of a problem, the program looks for a new limits card (Z_1, Z_2) in the card reader.

All other switches are ignored

SAMPLE PROBLEM - FRAME BENDING PROGRAM

Data for Sample Problem - Frame No. 1234

$$F(Z) = -.00013834Z^3 - .00210378Z^2 - .330263Z + 36.0$$

$DIS = 3.0 \qquad S = 3.0$

$Z_1 = 14.0 \qquad Z_2 = 0.0$

1620 Typewriter Listing while executing sample problem:

```
260000200003RS
LOAD SUBROUTINES
ENTER DATA
```

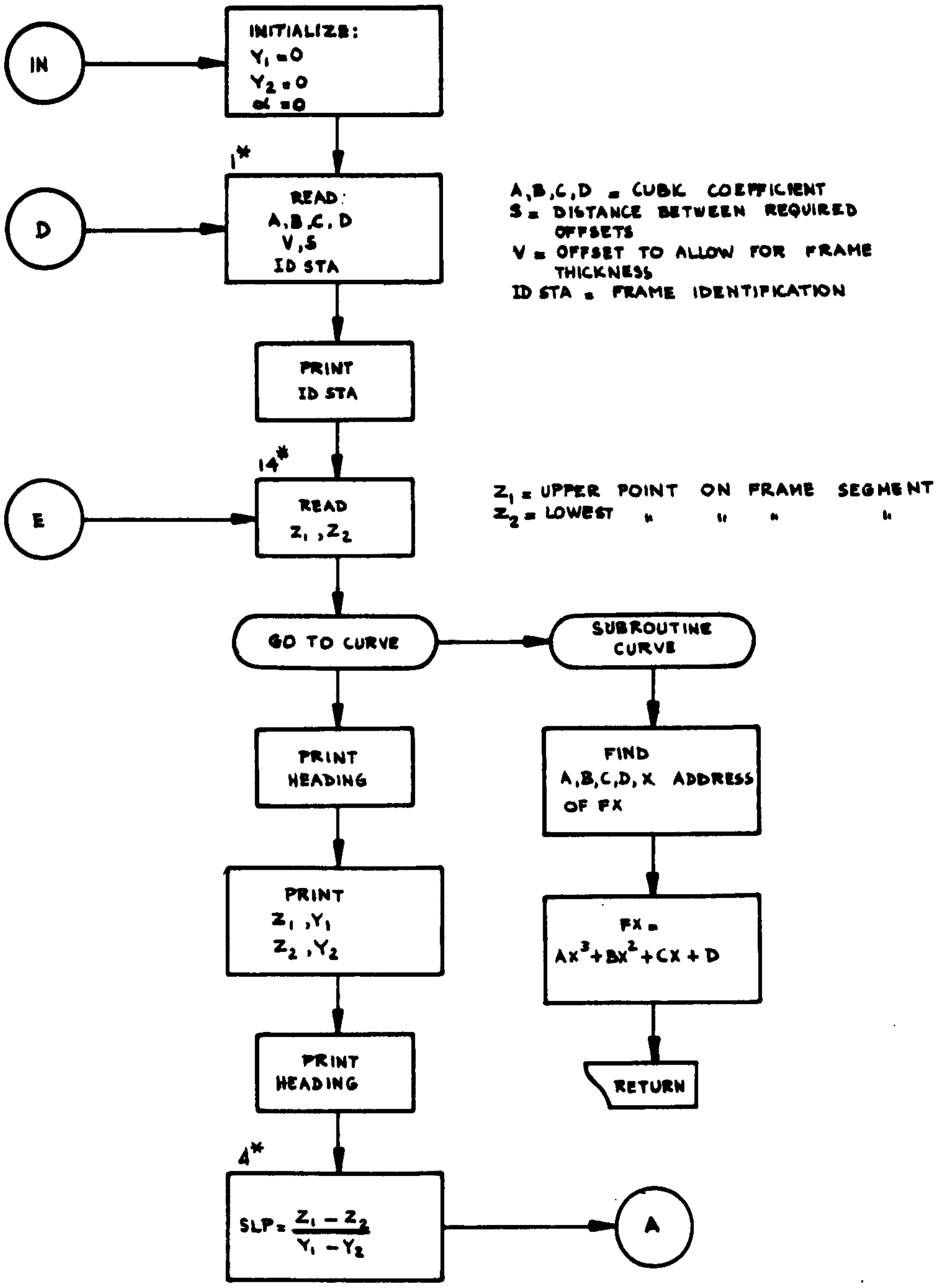
← Memory Clearing Instruction

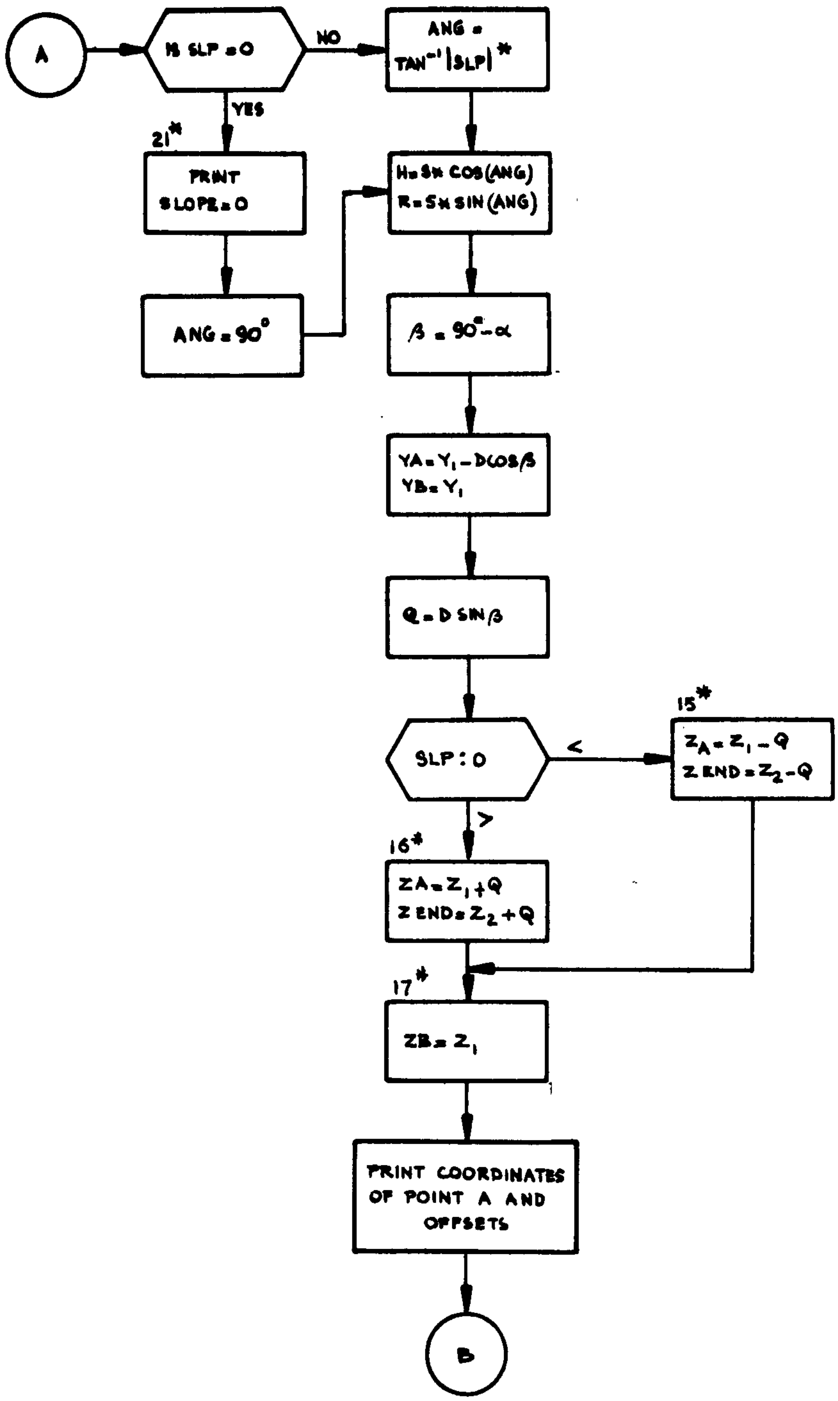
FRAME NO. 1234

Z(1)	Y(1)	Z(2)	Y(2)
14.00000	30.58437	0.00000	36.00000

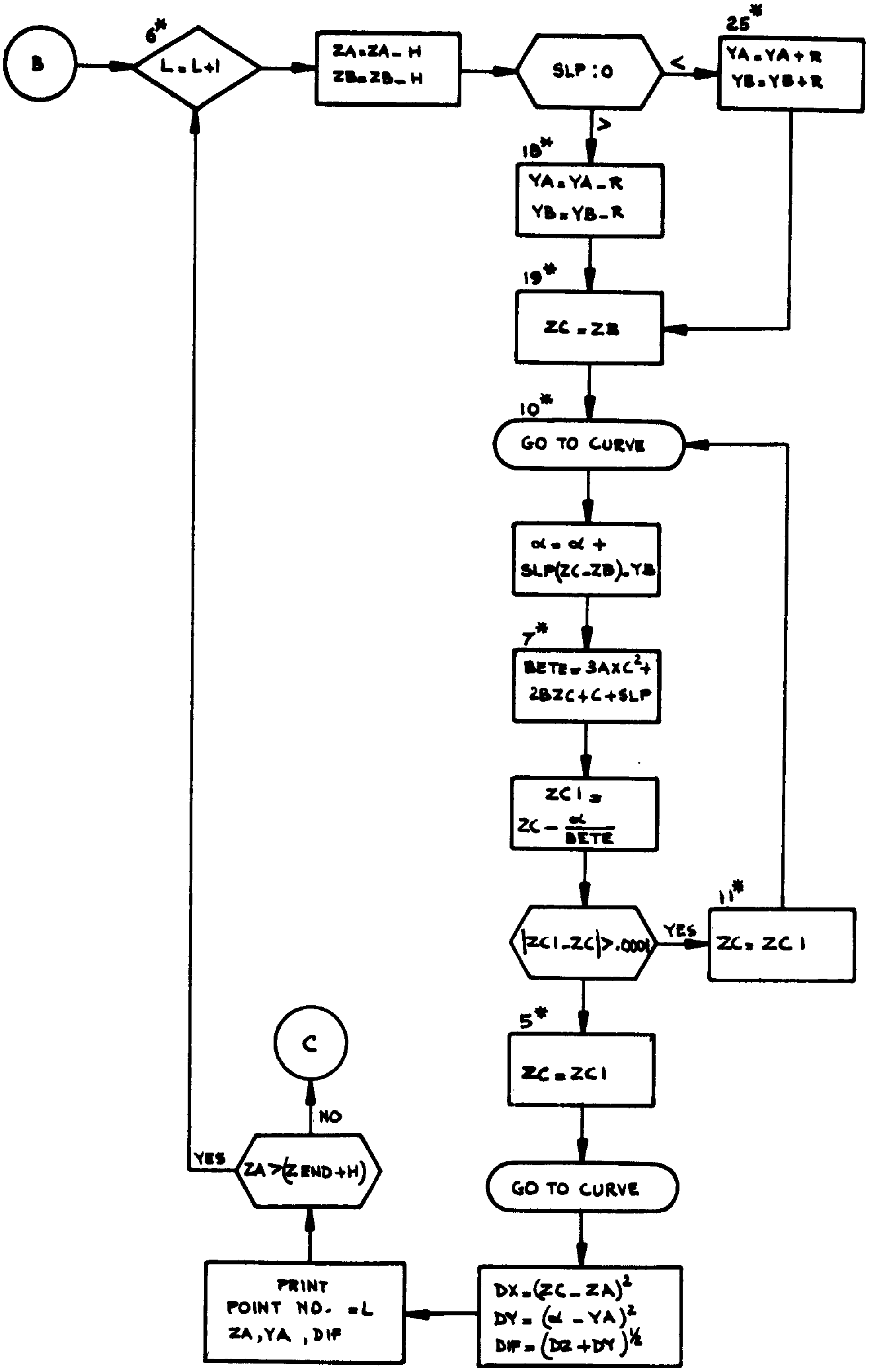
PT. NO.	Z	Y	PERP. DIST. TO CURVE
1	12.91815	27.78623	3.00000
2	10.12000	28.86807	3.16161
3	7.32185	29.94991	3.22862
4	4.52371	31.03175	3.21436
5	1.72556	32.11359	3.13377
6	-1.07258	33.19543	3.00320
7	-1.08185	33.20185	3.00000

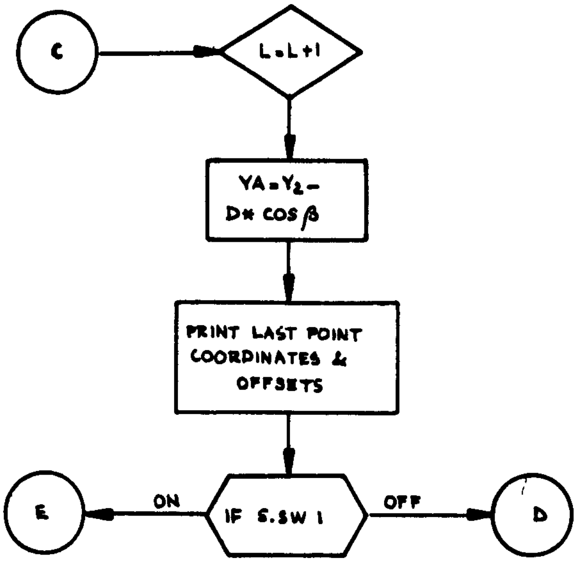
PROGRAM FLOW CHART -
CALCULATION OF OFFSETS FOR FRAME BENDING TEMPLATES





* ARCTANGENT FORMULA TAKEN FROM ....


B
6*
L = L+1
ZA = ZA - H
ZB = ZB - H
SLP : 0
<
25*
YA = YA + R
YB = YB + R
>
18*
YA = YA - R
YB = YB - R
19*
ZC = ZB
10*
GO TO CURVE
α = α + SLP(ZC - ZB) - YB
7*
BETE = 3AXC^2 + 2BZC + C + SLP
ZC1 = ZC - α/BETE
\|ZC1 - ZC\| > .0001
YES
11*
ZC = ZC1
5*
ZC = ZC1
GO TO CURVE
DX = (ZC - ZA)^2
DY = (α - YA)^2
DIF = (DZ + DY)^½
PRINT
POINT NO. = L
ZA, YA, DIF
ZA > (ZEND + H)
YES
NO
C


C
L=L+1
YA=Y2-
D* COS β
PRINT LAST POINT
COORDINATES &
OFFSETS
E
ON
IF S.SW 1
OFF
D

```
C       OFFSETS FOR FRAME BENDING
        DIMENSION Z(3),Y(3)
        Y(1)=0.0
        Y(2)=0.0
        ALPA=0.0
      1 READ 100,A,B,C,D,DIS,S,IDSTA
        PRINT 105,IDSTA
     14 READ 101,Z(1),Z(2)
        CALL CURVE(A,B,C,D,Y(1),Z(1))
        CALL CURVE(A,B,C,D,Y(2),Z(2))
        PRINT 106
        PRINT 102,Z(1),Y(1),Z(2),Y(2)
        PRINT 104
      4 SLP=(Z(1)-Z(2))/(Y(1)-Y(2))
        PSLP=-SLP
        SP=ABSF(SLP)
        PM=SP-1.
        PL=SP+1.
        IF(SLP)26,21,26
     26 ANG=.7853982+.995354*(PM/PL)-.288679*((PM/PL)**3)
        ANG=ANG+.079331*((PM/PL)**5)
     23 H=S*SINF(ANG)
        R=S*COSF(ANG)
        BANG=(1.5708-ANG)
        YA=Y(1)-DIS*COSF(BANG)
        YB=Y(1)
        Q=DIS*SINF(BANG)
        IF(SLP)15,16,16
     15 ZA=Z(1)-Q
        ZEND=Z(2)-Q
        GO TO 17
        16 ZA=Z(1)+Q
        ZEND=Z(2)+Q
     17 ZB=Z(1)
        L=1
        PRINT 103,L,ZA,YA,DIS
      6 L=L+1
        ZA=ZA-H
        ZB=ZB-H
        IF(SLP)25,18,18
     25 YA=YA+R
        YB=YB+R
        GO TO 19
     18 YA=YA-R
```

```
      YB=YB-R
   19 ZC=ZB
   10 CALL CURVE(A,B,C,D,ALPA,ZC)
      ALPA=ALPA-PSLP*(ZC-ZB)-YB
    7 BETE=3.*A*ZC*ZC+2.*B*ZC+C-PSLP
      ZC1=ZC-(ALPA/BETE)
      IF(ABSF(ZC1-ZC)-.0001)5,5,11
   11 ZC=ZC1
      GO TO 10
    5 ZC=ZC1
      CALL CURVE(A,B,C,D,ALPA,ZC)
    8 DZ=(ZC-ZA)*(ZC-ZA)
      DY=(ALPA-YA)*(ALPA-YA)
      DIF=SQRTF(DZ+DY)
      PRINT 103,L,ZA,YA,DIF
      IF(ZA-ABSF(ZEND+ABSF(H)))9,6,6
    9 L=L+1
      YA=Y(2)-DIS*COSF(BANG)
      PRINT 107,L,ZEND,YA,DIS
   22 IF(SENSE SWITCH 1)14,1
   21 PRINT 108
      ANG=1.5708
      GO TO 23
  100 FORMAT(4F15.8,2F7.3,I5)
  101 FORMAT(2F10.5)
  102 FORMAT(4F10.5/)
  103 FORMAT(I4,10X,F10.5,2X,F10.5,13X,F10.5)
  104 FORMAT(7HPT. NO.,10X,1HZ,12X,1HY,10X,20HPERP. DIST. TO CURVE)
  105 FORMAT(9HFRAME NO.,I5/)
  106 FORMAT(3X,4HZ(1),7X,4HY(1),7X,4HZ(2),7X,4HY(2))
  107 FORMAT(I4,10X,F10.5,2X,F10.5,13X,F10.5/)
  108 FORMAT(20H   SLOPE EQUALS ZERO)
      END


      SUBROUTINE CURVE(A,B,C,D,FX,X)
      FX=A*X*X*X+B*X*X+C*X+D
      RETURN
      END
```

Appendix I

DECK OFFSETS ROUTINE

CONTENTS

Appendix I

DECK OFFSETS ROUTINE

INTRODUCTION

The purpose of this program is to provide vertical deck camber offsets describing some standard deck forms easily expressed mathematically. The configurations which this program handles are:

- Straight line sheer and straight line camber
- Straight line sheer and parabolic camber
- Parabolic sheer and parabolic camber

The program is intended to be as general as possible within the confines of the above cases. It is possible to vary the frame spacing along the length of the ship and to vary the transverse interval between offsets. It is also possible to have variations in slope of the straight sheer line and to put knuckles in the straight line camber.

FORMULAS

The offsets calculated by this program are vertical offsets, whose base plane is a horizontal plane at a height above the base line of the ship, equal to the height of the lowest point on the sheer curve. The formulas for finding the height of the deck at the centerline are given below:

(1) The height of the deck at the centerplane amidships

$$h_n = .04\ Y_n = 2y_n(.24)/12$$

where y_n is the molded halfbreadth amidship

(2) The height of the deck at the centerplane and at the forward perpendicular

$$h_f = (.2P_L + 20)/12$$

where P_1 is the length between perpendiculars

(3) The height at the aft perpendicular

$$h_a = (.1P_L + 10)/12$$

Figure 1 gives the configuration of the decks in the longitudinal direction. Figure 2 presents the cross sections of the decks. The definitions of the symbols used are the same as given in the FORTRAN Input Symbol Definitions.

The program is written in Fortran II for the IBM-1620 computer.

INPUT DATA

Input Symbol Definition

Symbol		Definition
D	-	Distance from the midship section of the ship to the section that has the lowest freeboard (lowest point on the sheer profile). D is negative if this point is aft of midship.
PL	-	Ship's length between perpendiculars
P	-	Overall length of the ship
YM	-	The maximum molded half-breadth of the ship
DIST	-	Difference in length between the overall length of the ship measured forward from midship and the length between perpendiculars measured forward from midship.
CST	-	Length of the transverse interval between two deck offsets (Fig. 2-a).
L1	-	For the cases having straight sheer, this is the number of different slopes in the sheer line forward of midship. (L1 = 3 in Fig. 1-b).
L2	-	Same as L1, except aft of midship (L2 - 2 in Fig. 1-b).
L3	-	For the cases having straight camber, this is the number of different slopes in the camber from the center plane to the sheer line (L3 = 2 in Fig. 2-b).
L4	-	The number of intervals of different frame spacing forward of the section with minimum freeboard. The minimum number of intervals must be 2. That is,

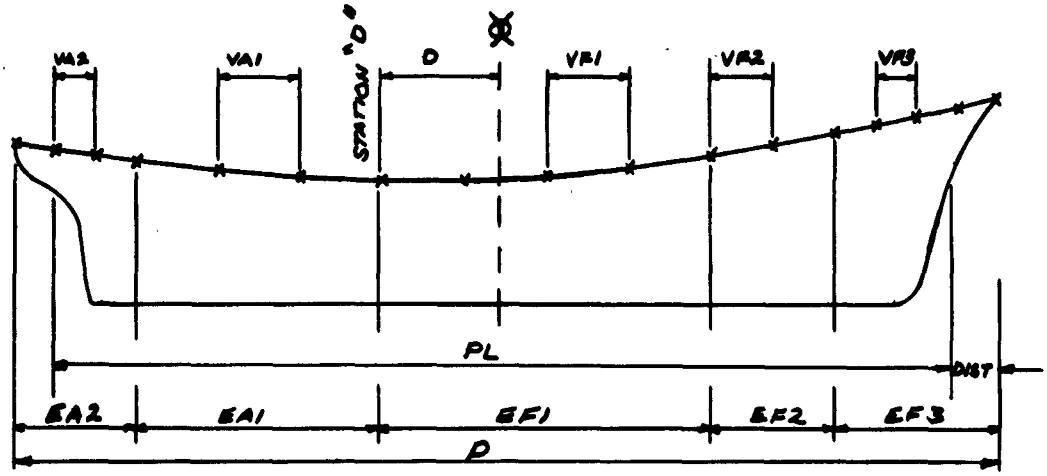

VA2
VA1
STATION "D"
D
VF1
VF2
VF3
PL
DIST
EA2
EA1
EF1
EF2
EF3
P

FIG. 1a

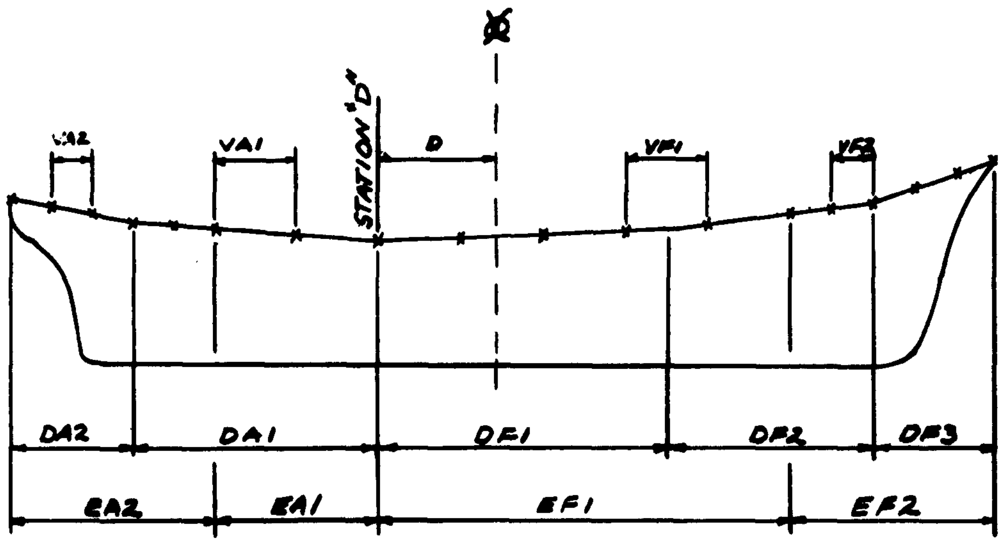

VA2
VA1
STATION "D"
D
VF1
VF2
DA2
DA1
DF1
DF2
DF3
EA2
EA1
EF1
EF2

FIG. 1b

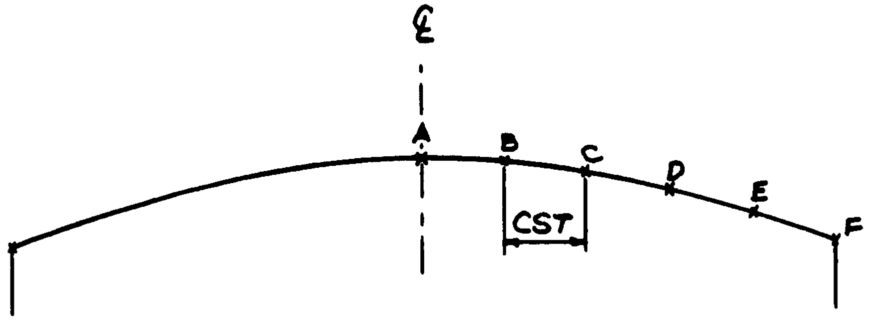


FIG. 2a

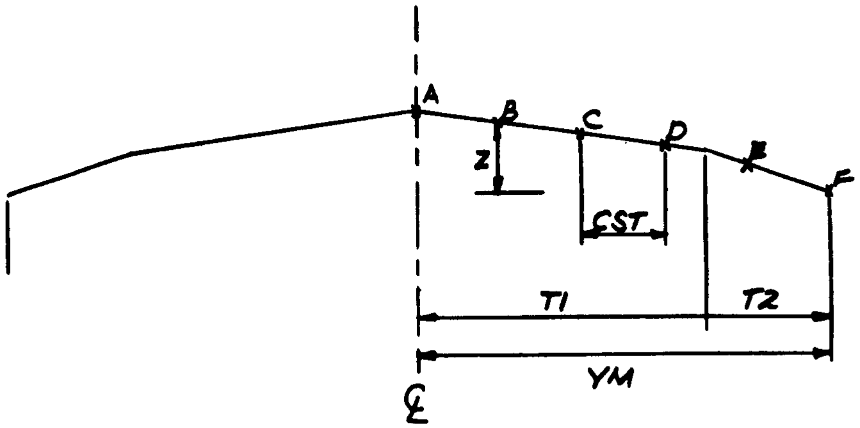


FIG. 2b

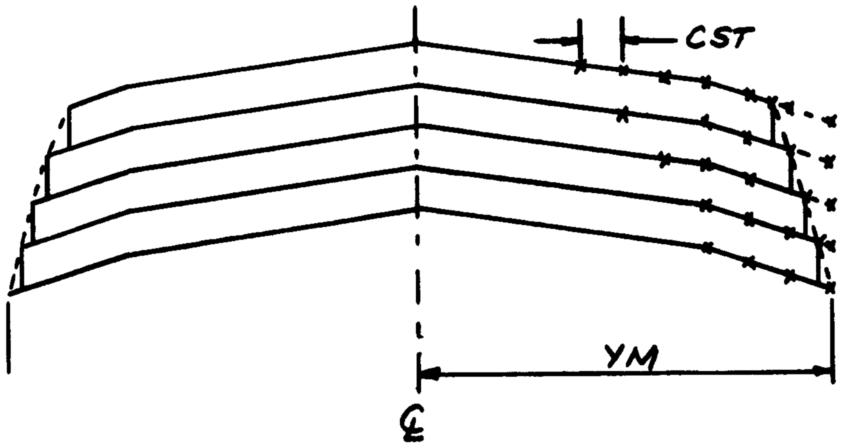


FIG. 2c

there must be at least one change in frame spacing.

L5 - The number of intervals of different frame spacing used aft of the section of minimum freeboard. The maximum number is 2 .

DB - Length of each different slope (corresponding to L1) from midships forward. Each DF is presented in order starting at midship and working forward.

DA - Same as DF (corresponds to L2) starting at midship and working aft.

E - Length in feet of each longitudinal section having a different station spacing (corresponds to L4) starting at the point of minimum freeboard at working forward.

V - The interval between frames in each section E above.

EA - Same as E , except aft (corresponds to L5)

VA - Same as V , except aft

T - Length in feet of each of the slopes (corresponds to L3) from the centerline plane to the sheer line.

Input Data Cards

There are four different sets of data specified for this program, one set for each of the four cases given in the introduction.

The limitations on those variables which have dimension restrictions are given below.

Variable	Minimum	Maximum
E , EA	2	20
V , VA	2	20
DB , DA	1	21
T	1	21

The actual FORTRAN format field descriptions have been used to describe the data cards. The field descriptions are the FORTRAN F field, which contains a fixed point decimal number, and the I field, which contains an integer number that is always right justified.

A. Parabolic Sheer and Camber

Card 1 (This card is a header card. For this case it contains a 1 in Column 5)

Card 2

Format	F15.9	F15.9	F15.9	F15.9	F15.9
Columns	1-15	16-30	31-45	46-60	61-75
Variable	D	PL	P	YM	DIST

Card 3

Format	F15.9	I5	I5
Columns	1-15	16-20	21-25
Variable	CST	L4	L5

Next L4 Cards

Format	F15.9	F15.9
Columns	1-15	16-30
Variable	E	V

Next L5 Cards

Format	F15.9	F15.9
Columns	1-15	16-30
Variable	EA	VA

B. Straight Sheer and Camber

Card 1 (Header card contains a 2 in Column 5)

Card 2

Format	F15.9	F15.9	F15.9	F15.9	F15.9
Columns	1-15	16-30	31-45	46-60	61-75
Variable	D	PL	P	YM	DIST

Card 3

Format	F15.9	I5	I5	I5	I5	I5
Columns	1-15	16-20	21-25	26-30	31-35	36-40
Variable	CST	L1	L2	L3	L4	L5

Next L1 Cards

Format	F15.9
Columns	1-15
Variable	DB

Next L2 Cards

Format	F15.9
Columns	1-15
Variable	DA

Next L3

Format	F15.9
Columns	1-15
Variable	T

Next L4 Cards

Format	F15.9	F15.9
Columns	1-15	16-30
Variable	E	V

Next L5 Cards

Format	F15.9	F15.9
Columns	1-15	16-30
Variable	EA	VA

C. Straight Sheer and Parabolic Camber

Card 1 (Header card; contains a 3 in Column 5)

Card 2

Format	F15.9	F15.9	F15.9	F15.9	F15.9
Columns	1-15	16-30	31-45	46-60	61-75
Variable	D	PL	P	YM	DIST

Card 3

Format	F15.9	I5	I5	I5	I5
Columns	1-15	16-20	21-25	26-30	31-35
Variable	CST	L1	L2	L4	L5

Next L1 Cards

Format	F15.9
Columns	1-15
Variable	DB

Next L2 Cards

Format	F15.9
Columns	1-15
Variable	DA

Next L4 Cards

Format	F15.9	F15.9
Columns	1-15	16-30
Variable	E	V

Next L5 Cards

Format	F15.9	F15.9
Columns	1-15	16-30
Variable	EA	VA

D. <u>Parabolic Sheer and Straight Camber</u>

Card 1 (Header card; contains a 4 in Column 5)

Card 2

Format	F15.9	F15.9	F15.9	F15.9	F15.9
Columns	1-15	16-30	31-45	46-60	61-75
Variable	D	PL	P	YM	DIST

Card 3

Format	F15.9	I5	I5	I5
Columns	1-15	16-20	21-25	26-30
Variable	CST	L3	L4	L5

Next L4 Cards

Format	F15.9	F15.9
Columns	1-15	16-30
Variable	E	V

Next L5 Cards

Format	F15.9	F15.9
Columns	1-15	16-30
Variable	EA	VA

OUTPUT

All the output will be punched on cards. The deck height offsets of Section D will be punched first, followed by those of the sections forward of D . After completing these sections the message "Deck Offsets Aft" will be punched. The message will be followed by the offsets from the section just aft of D to the stern.

For each section the program will punch offsets out to the halfbreadth (YM). At stations forward and aft of the midship station (or parallel middlebody) some of these offsets will not be valid since they will lie outside the sheer line.

SENSE SWITCH SETTINGS

All the sense switches are normally off, with one exception. The value of the transverse interval between offsets (CST) can be changed during execution by turning Switch 3 on. The program will halt and wait for a new value of CST to be typed in (Format F15.9). Switch 3 must be turned off before pushing start to continue.

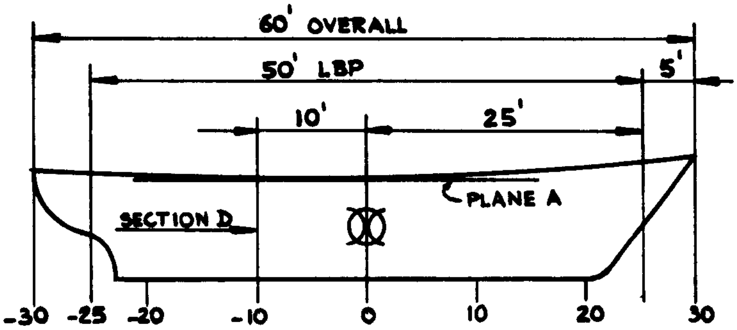
SAMPLE PROBLEM

Input Data

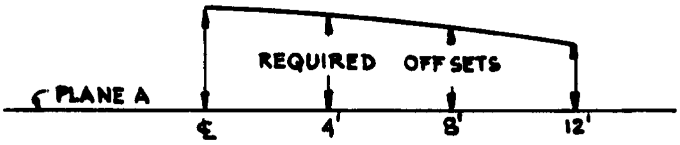
```
  1
-10.0          50.0            60.0           12.0          5.0
  4.0           2      2
 20.0          10.0
 20.0          10.0
 10.0          10.0
 10.0           5.0
```

Output

```
DECK OFFSETS FORWARD.-
FRAME    -10.0000
      .47999999
      .42666666
      .26666667
      .00000001
FRAME      0.0000
      .64489794
      .59156461
      .43156462
      .16489796
FRAME     10.0000
     1.13959170
     1.08625840
      .92625847
      .65959181
FRAME     20.0000
     1.96408150
     1.91074810
     1.75074810
     1.48408150
FRAME     30.0000
     3.11836710
     3.06503380
     2.90503380
     2.63836720
DECK OFFSETS AFT.-
FRAME    -20.0000
      .82222223
      .76888893
      .60888893
      .34222233
FRAME    -25.0000
     1.24999990
     1.19666660
     1.03666660
      .77000003
FRAME    -30.0000
     1.84888870
     1.79555540
     1.63555540
     1.36888880
```

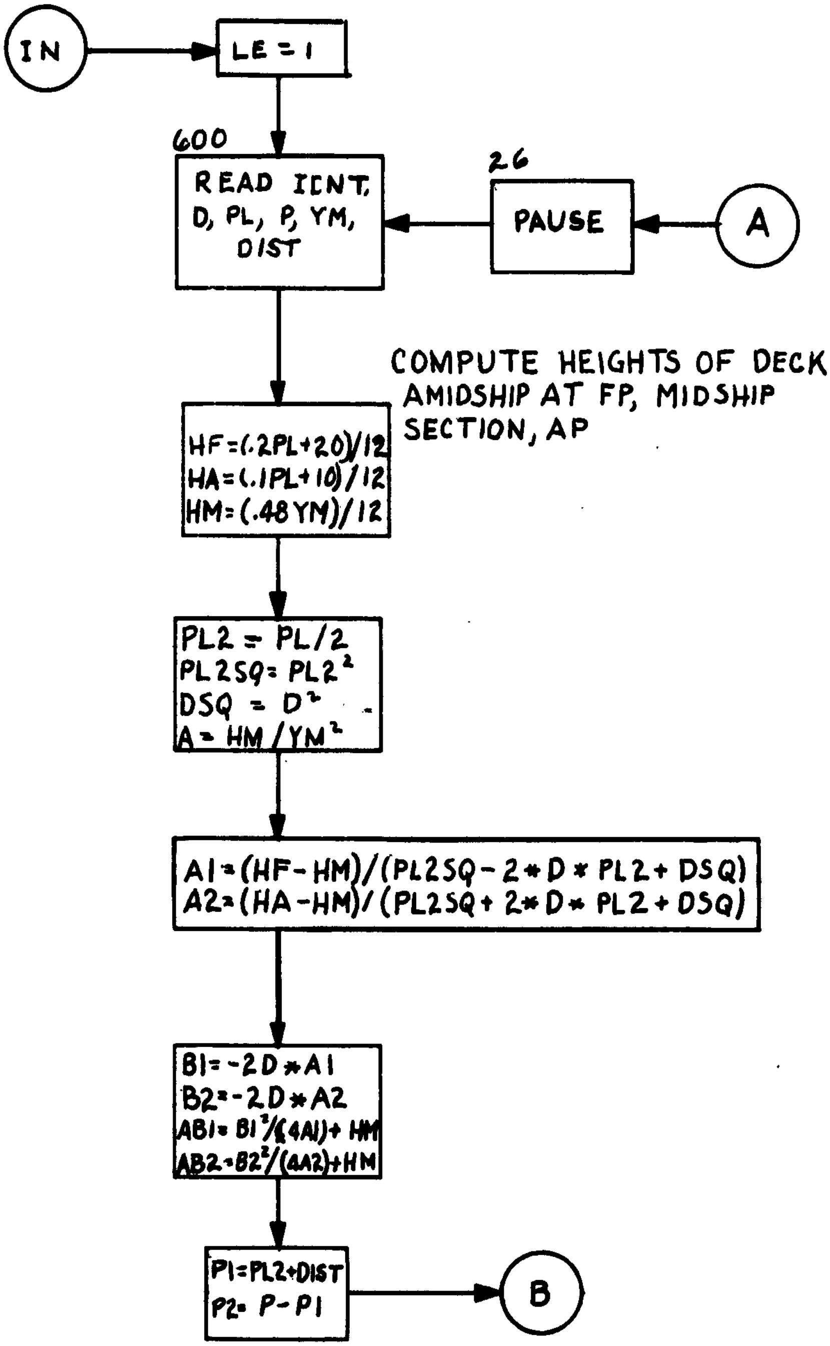


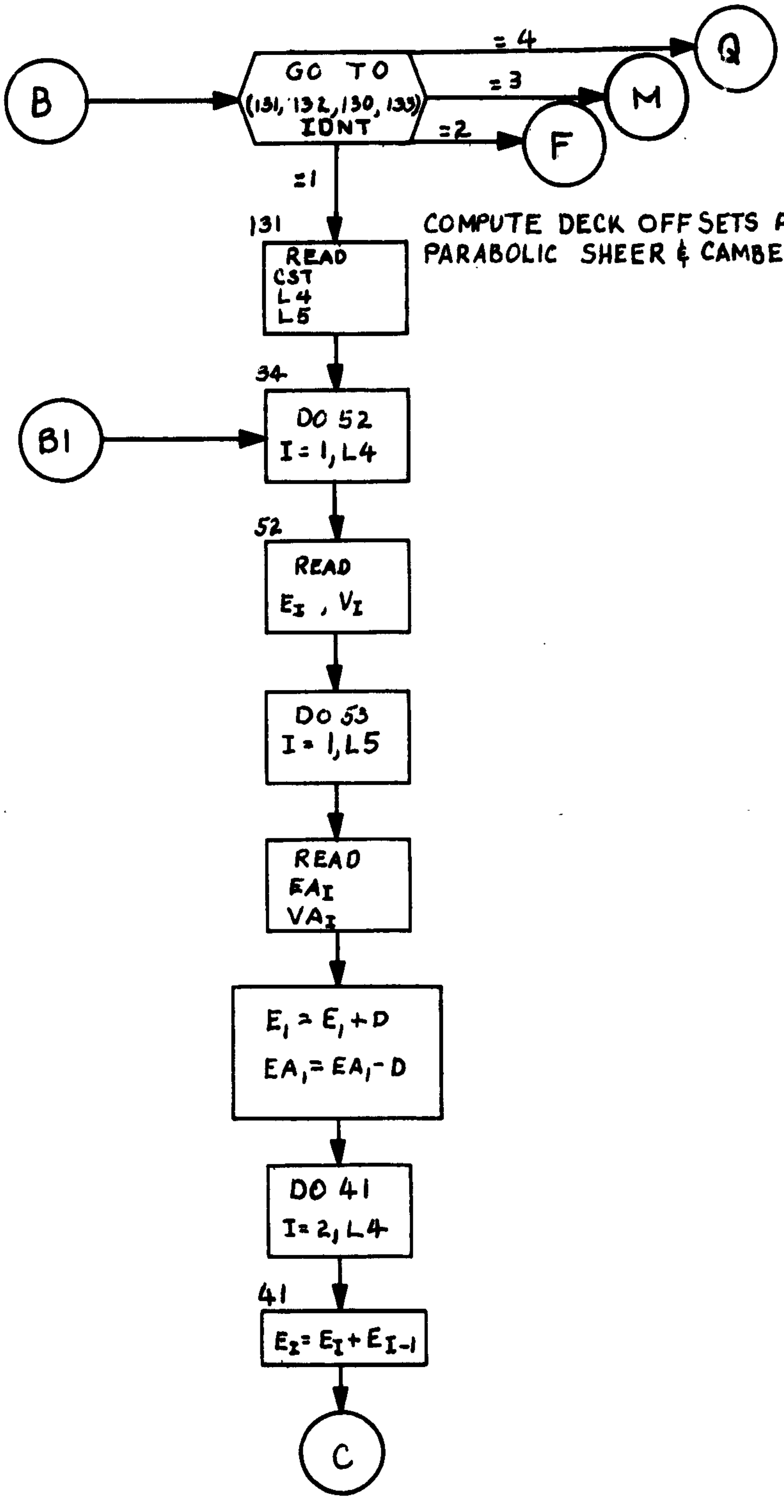
SIDE VIEW OF SAMPLE PROBLEM



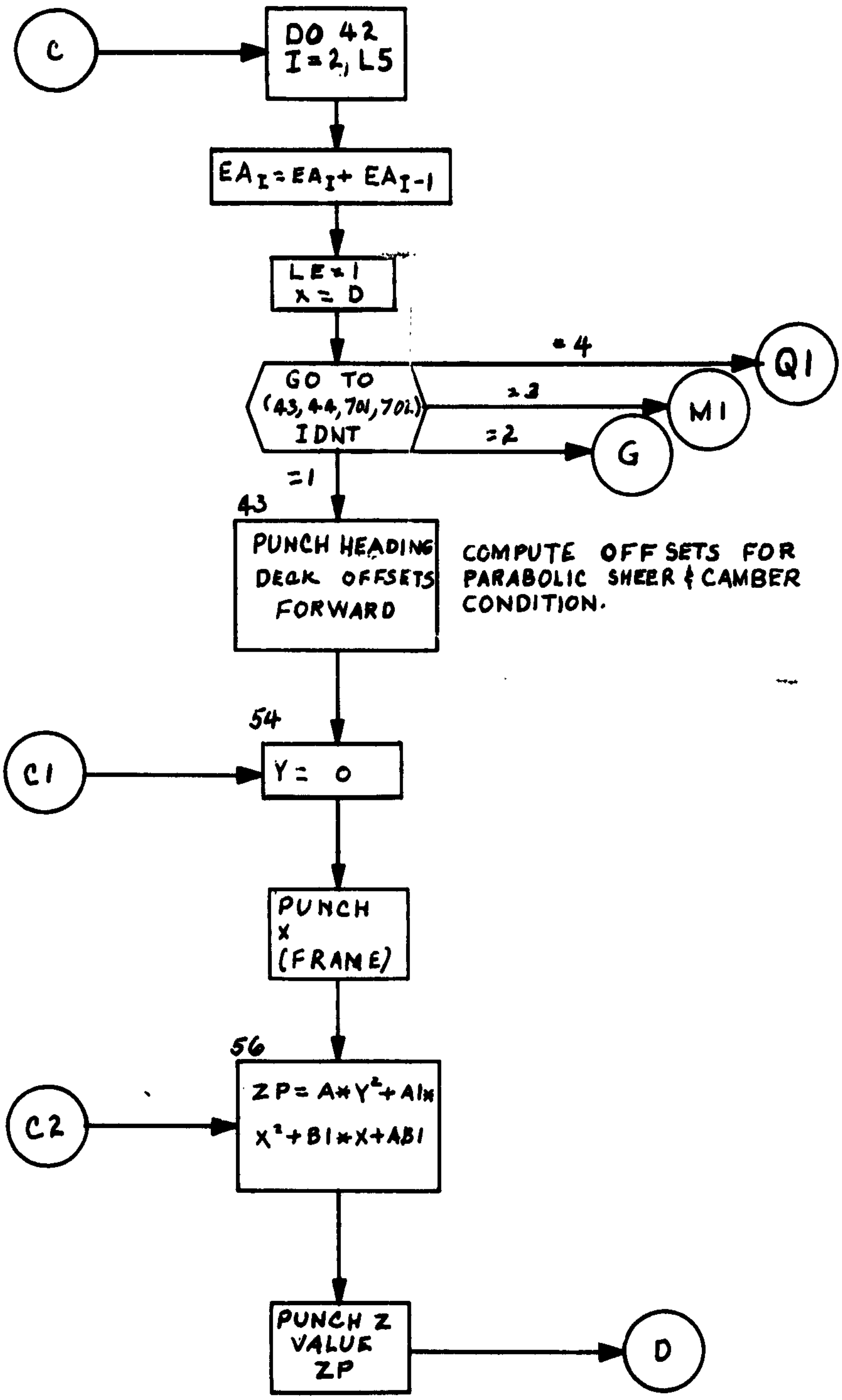
CROSS SECTION OF DECK

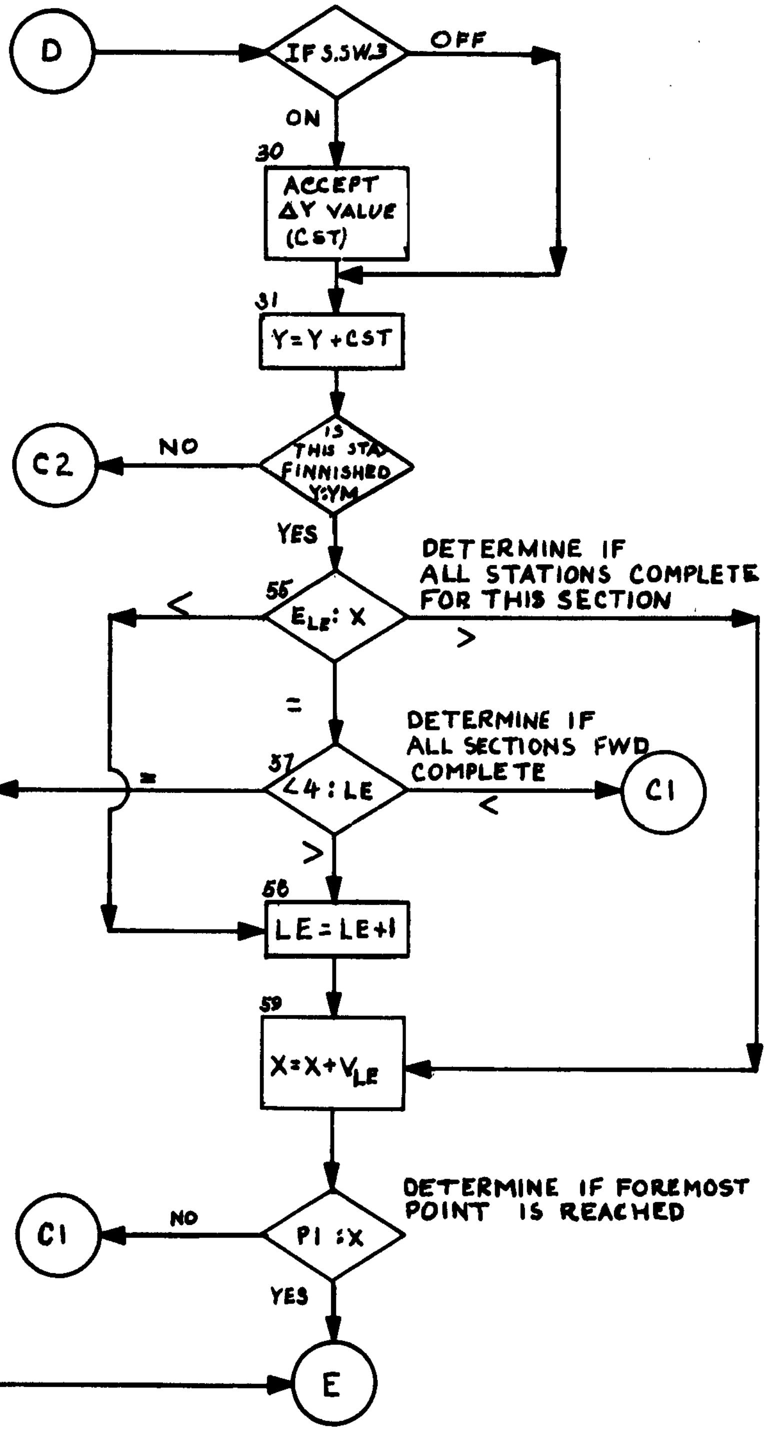
FLOW DIAGRAM

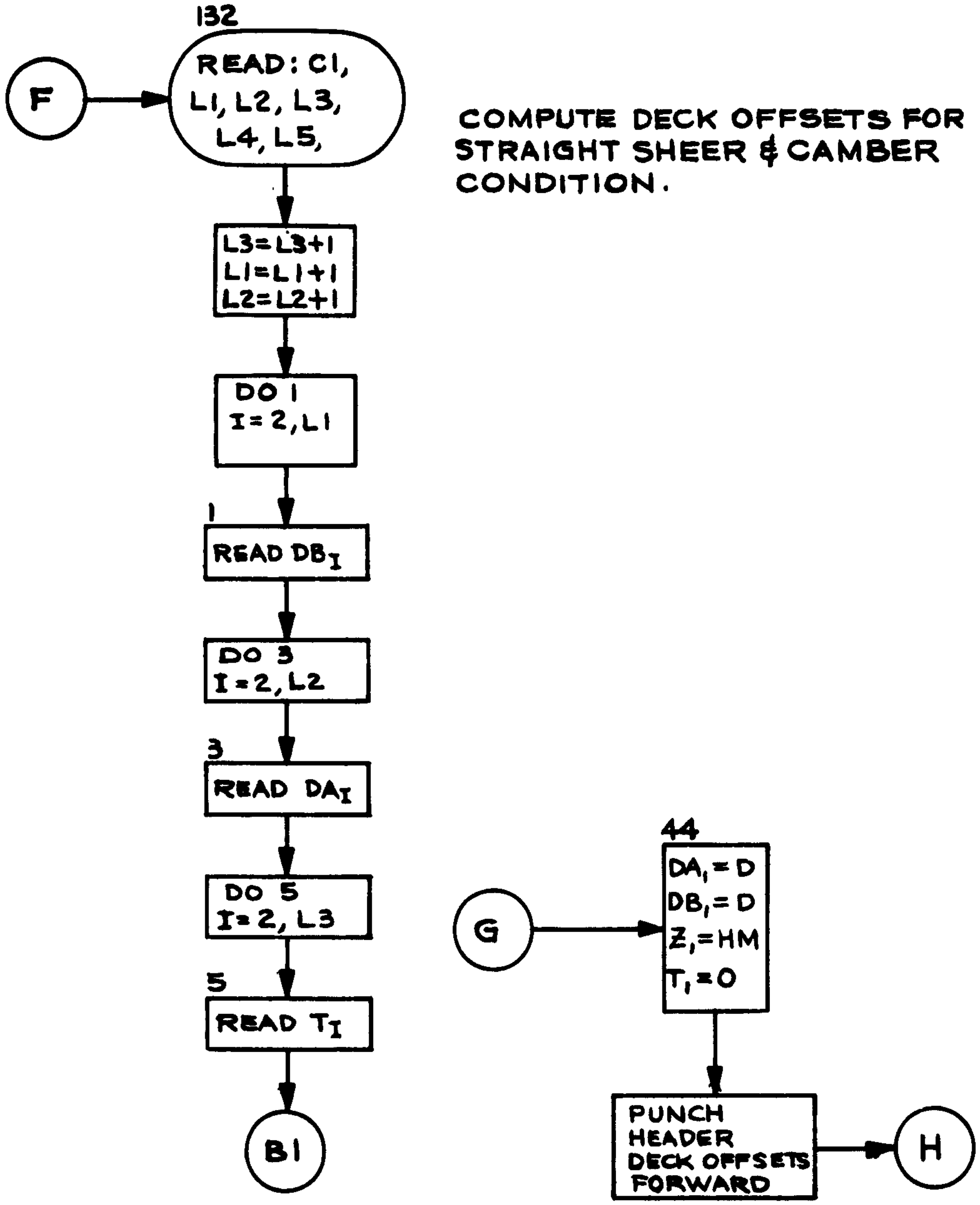


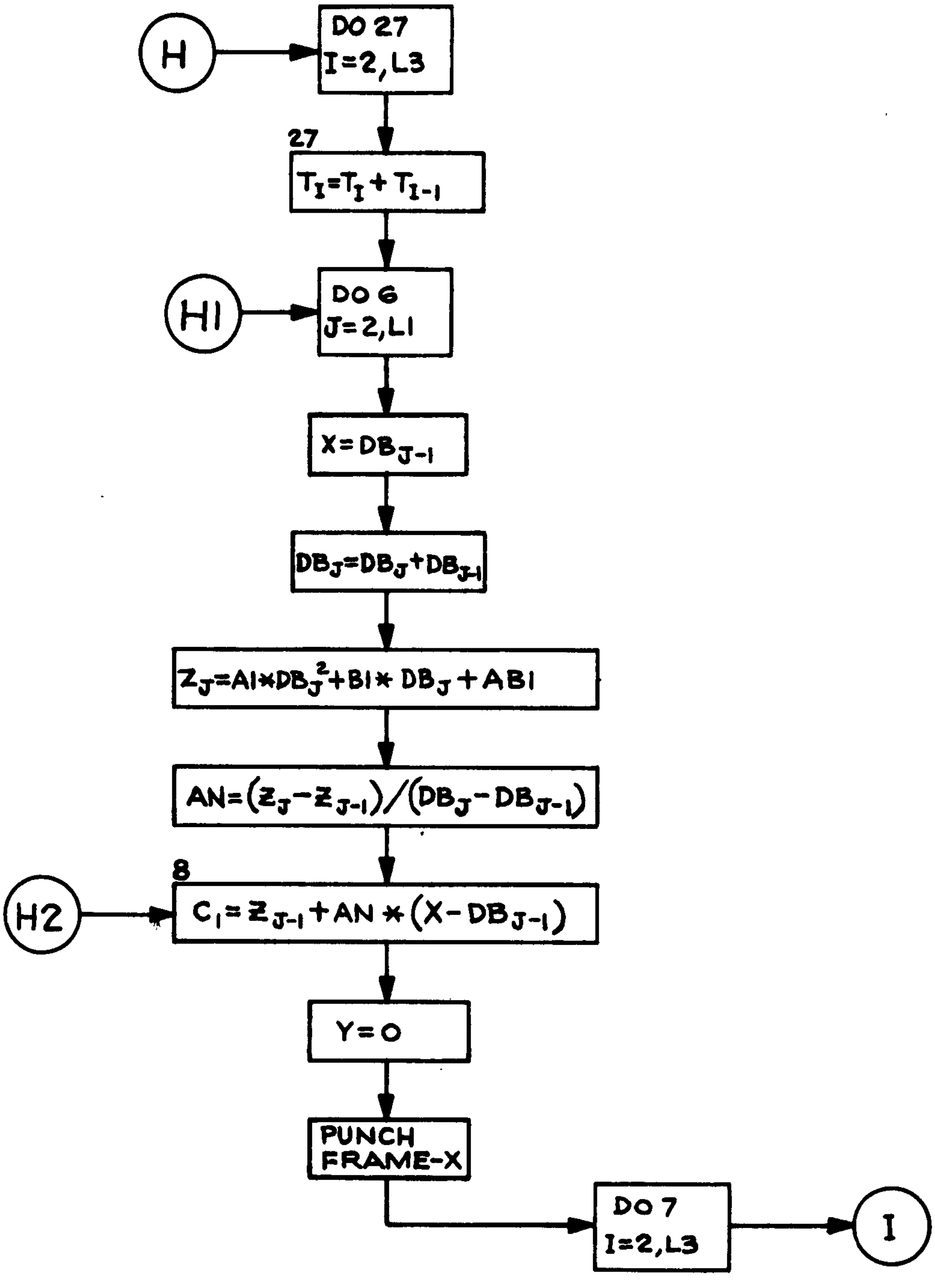


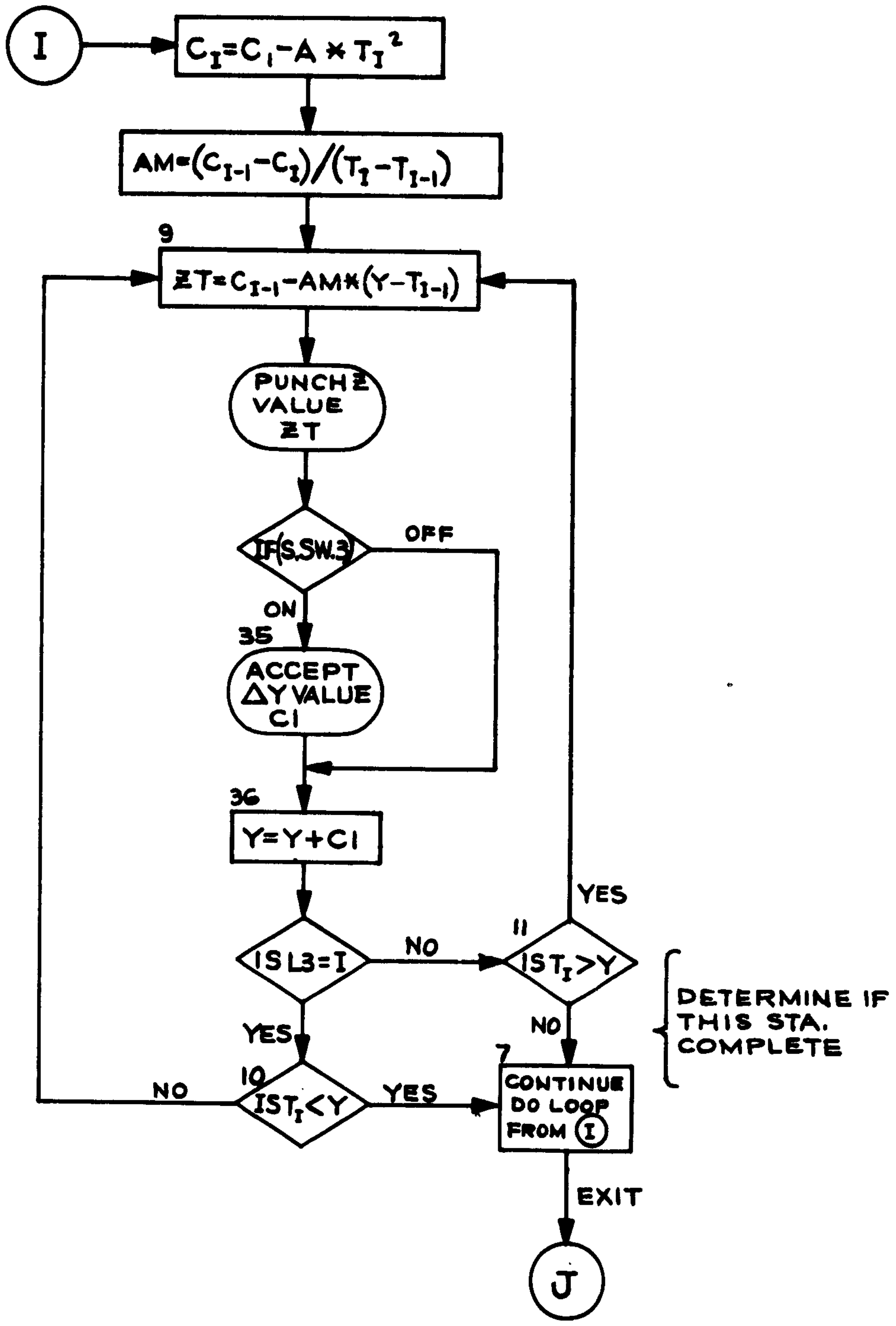
GO TO
(131, 132, 130, 133)
IDNT
=4
=3
=2
=1
B
Q
M
F
131
COMPUTE DECK OFFSETS FOR PARABOLIC SHEER & CAMBER
READ
CST
L4
L5
34
DO 52
I = 1, L4
B1
52
READ
E_I , V_I
DO 53
I = 1, L5
READ
EA_I
VA_I
$E_1 = E_1 + D$
$EA_1 = EA_1 - D$
DO 41
I = 2, L4
41
$E_I = E_I + E_{I-1}$
C

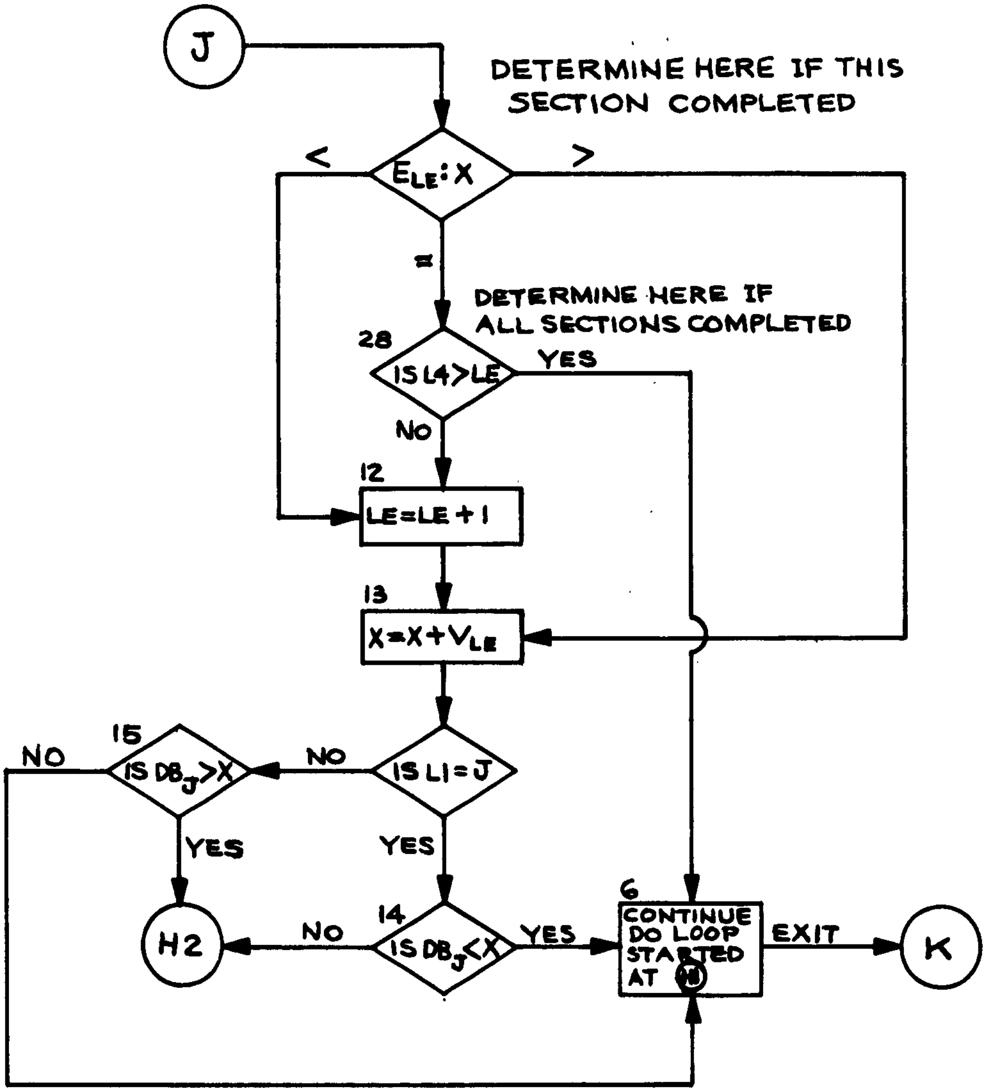

C
DO 42
I = 2, L5
$EA_I = EA_I + EA_{I-1}$
LE = 1
X = D
GO TO
(43, 44, 701, 702)
IDNT
= 4
= 3
= 2
= 1
Q1
M1
G
43
PUNCH HEADING
DECK OFFSETS
FORWARD
COMPUTE OFF SETS FOR
PARABOLIC SHEER & CAMBER
CONDITION.
54
C1
Y = 0
PUNCH
X
(FRAME)
56
C2
ZP = A*Y² + A1*
X² + B1*X + AB1
PUNCH Z
VALUE
ZP
D

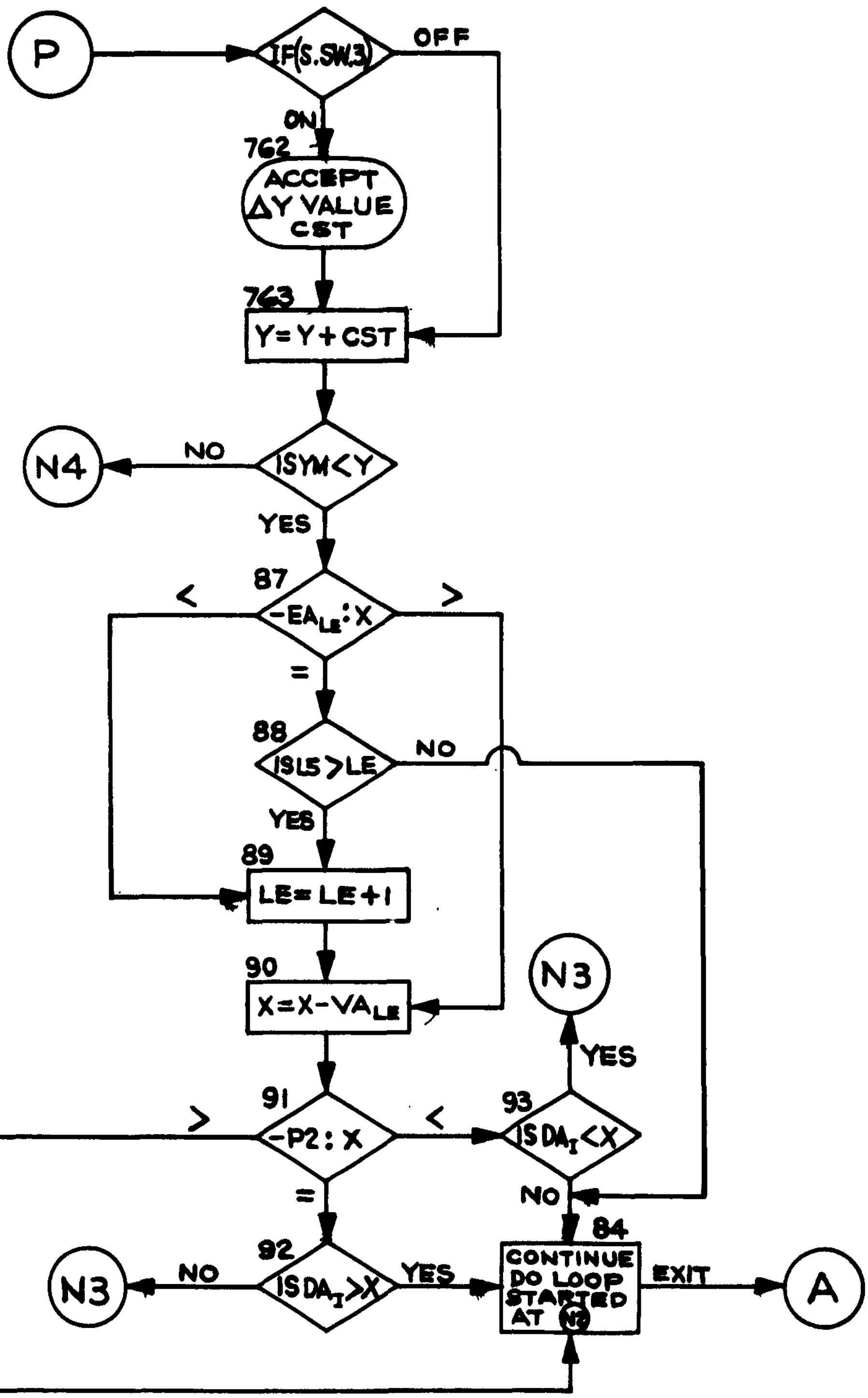

D
IF S.SW.3
OFF
ON
30
ACCEPT ΔY VALUE (CST)
31
Y=Y+CST
IS THIS STA FINNISHED Y:YM
NO
C2
YES
DETERMINE IF ALL STATIONS COMPLETE FOR THIS SECTION
55
E_LE : X
<
>
=
DETERMINE IF ALL SECTIONS FWD COMPLETE
57
<4 : LE
=
<
C1
>
58
LE=LE+1
59
X=X+V_LE
DETERMINE IF FOREMOST POINT IS REACHED
P1 : X
NO
C1
YES
E

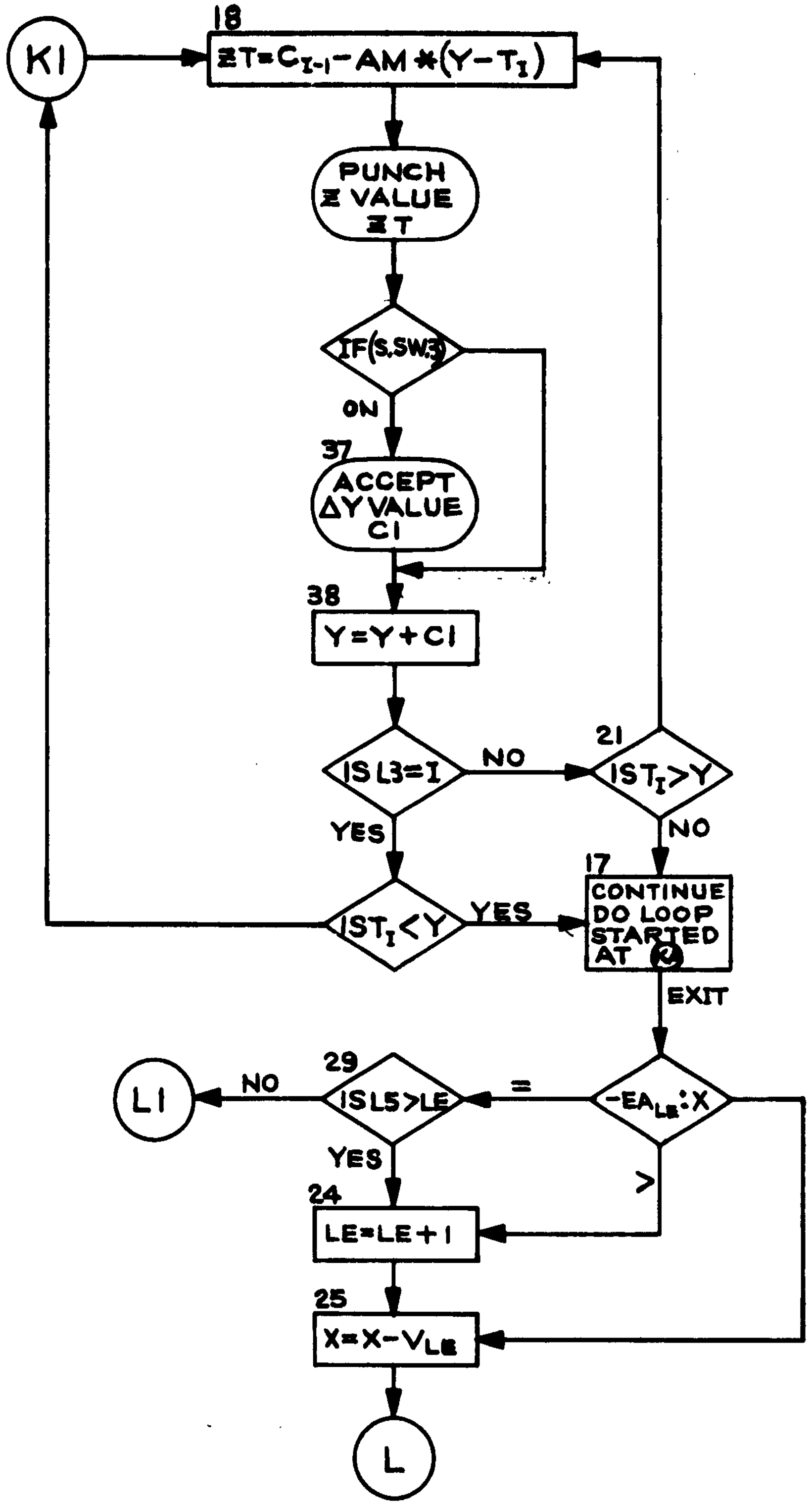

132
READ: C1, L1, L2, L3, L4, L5,
COMPUTE DECK OFFSETS FOR STRAIGHT SHEER & CAMBER CONDITION.
L3=L3+1
L1=L1+1
L2=L2+1
DO 1
I=2,L1
1
READ DB_I
DO 3
I=2,L2
3
READ DA_I
DO 5
I=2,L3
5
READ T_I
B1
F
G
44
DA_1 = D
DB_1 = D
Z_1 = HM
T_1 = 0
PUNCH HEADER DECK OFFSETS FORWARD
H

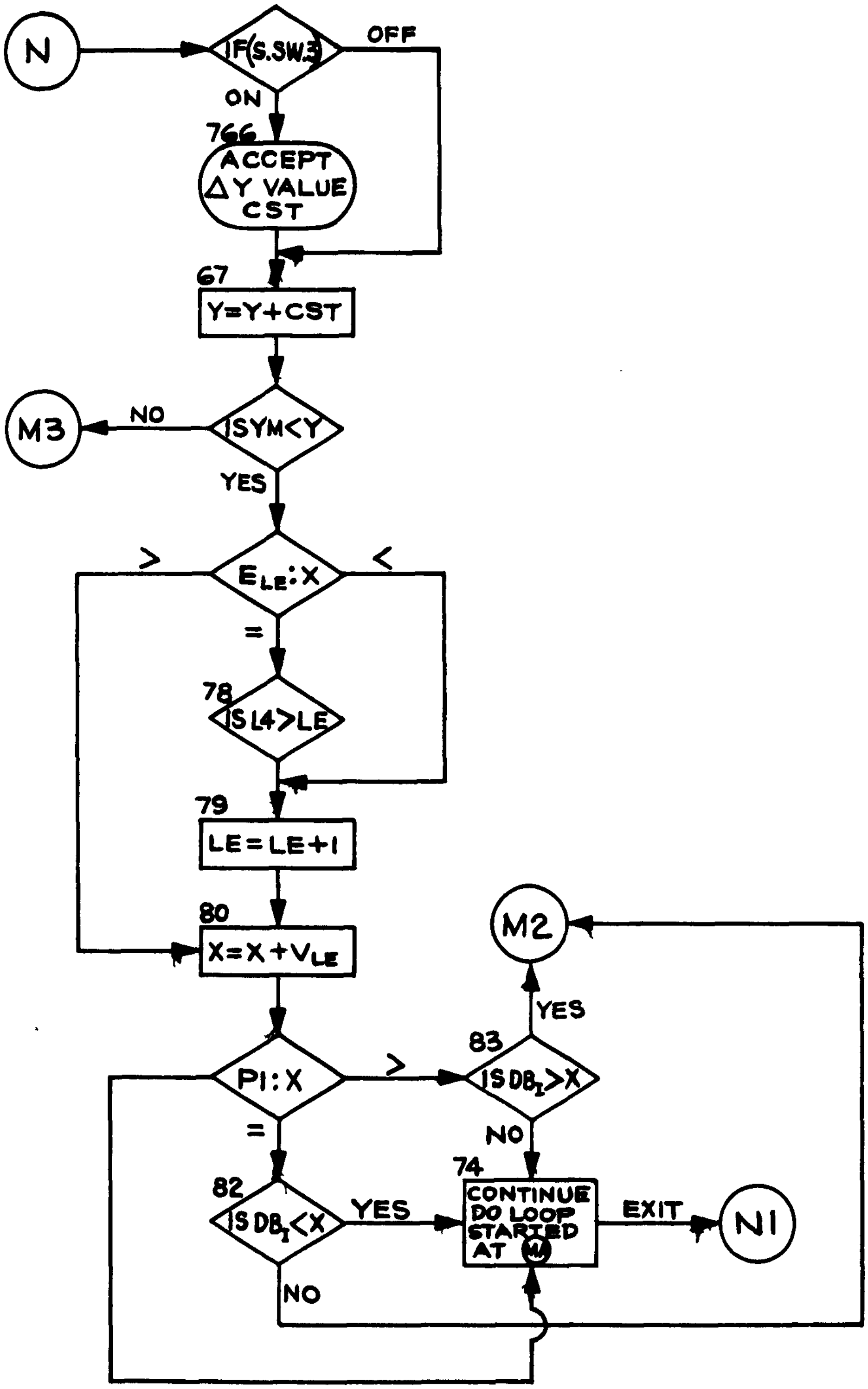

H
DO 27
I=2,L3
27
T_I=T_I+T_I-1
H1
DO 6
J=2,L1
X=DB_J-1
DB_J=DB_J+DB_J-1
Z_J=A1*DB_J^2+B1*DB_J+AB1
AN=(Z_J-Z_J-1)/(DB_J-DB_J-1)
8
H2
C_1=Z_J-1+AN*(X-DB_J-1)
Y=0
PUNCH
FRAME-X
DO 7
I=2,L3
I

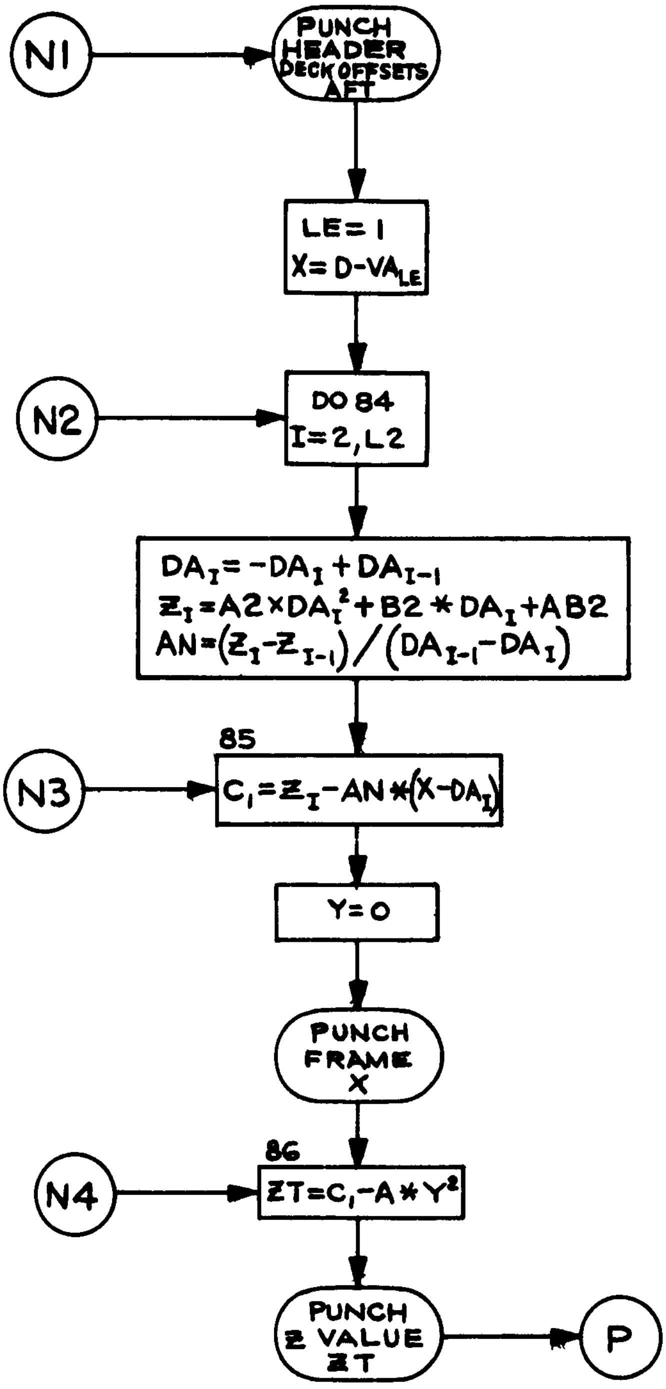

I
$C_I = C_1 - A * T_I^2$
$AM = (C_{I-1} - C_I)/(T_I - T_{I-1})$
9
$ZT = C_{I-1} - AM * (Y - T_{I-1})$
PUNCH Z VALUE ZT
IF(S.SW.3)
OFF
ON
35
ACCEPT ΔY VALUE CI
36
Y=Y+CI
IS L3=I
NO
YES
11
IS T_I>Y
YES
NO
DETERMINE IF THIS STA. COMPLETE
10
IS T_I<Y
NO
YES
7
CONTINUE DO LOOP FROM I
EXIT
J

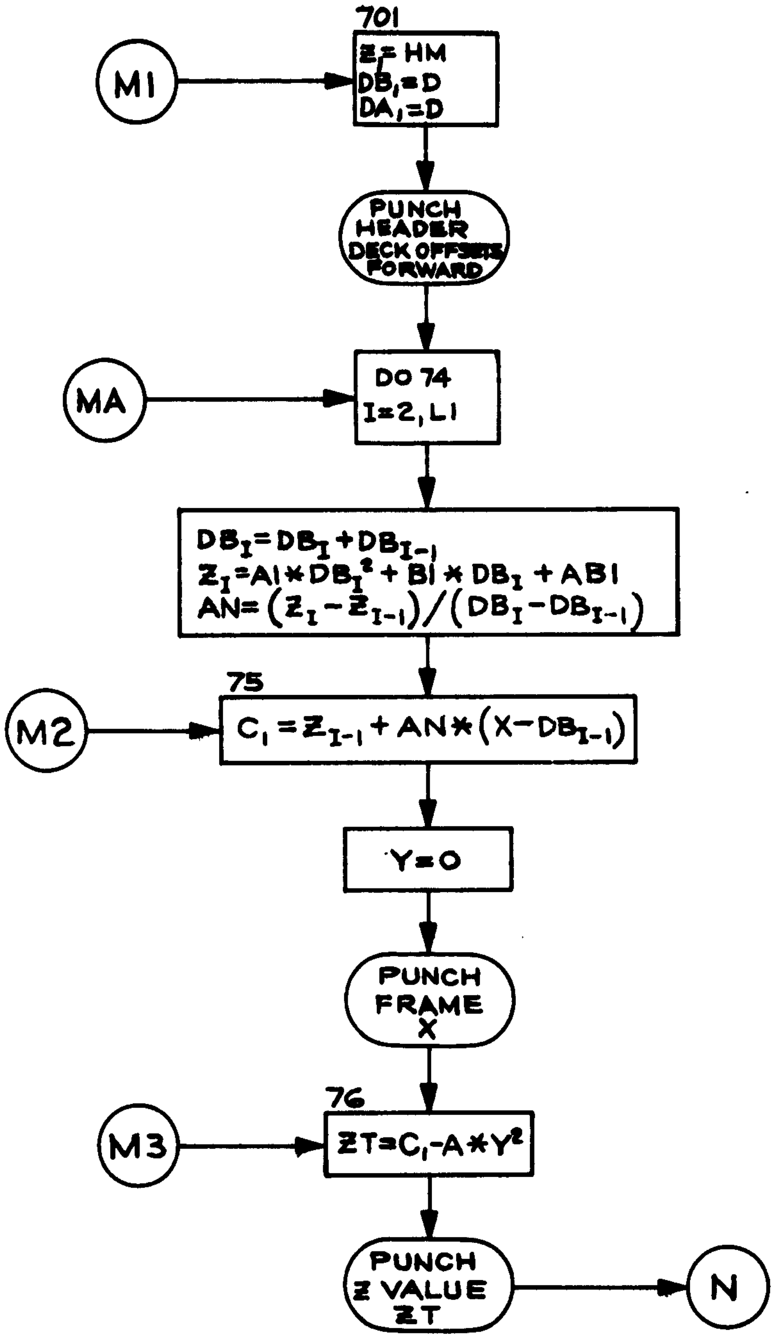

J
DETERMINE HERE IF THIS SECTION COMPLETED
<
$E_{LE}:X$
>
=
DETERMINE HERE IF ALL SECTIONS COMPLETED
28
IS L4>LE
YES
NO
12
LE=LE+1
13
$X=X+V_{LE}$
15
NO
IS $DB_J>X$
NO
IS L1=J
YES
YES
H2
NO
14
IS $DB_J<X$
YES
6
CONTINUE DO LOOP STARTED AT
EXIT
K

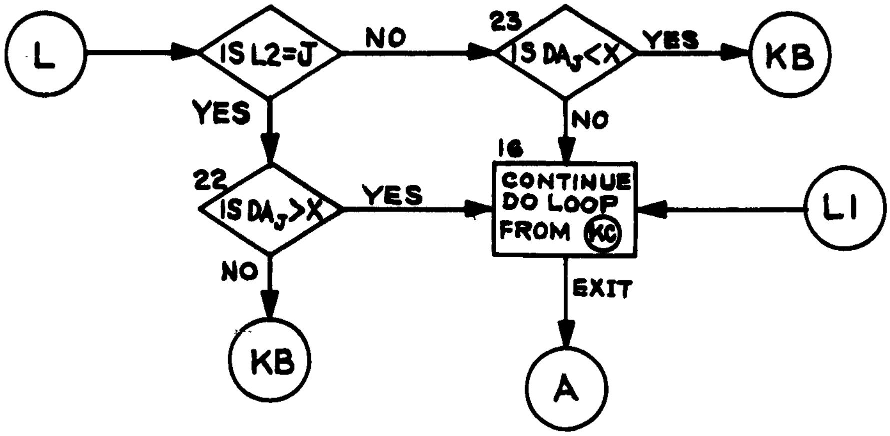

P
IF(S.SW.3)
OFF
ON
762
ACCEPT ΔY VALUE CST
763
Y=Y+CST
N4
NO
ISYM<Y
YES
87
<
-EA_LE : X
>
=
88
ISL5>LE
NO
YES
89
LE=LE+1
90
X=X-VA_LE
N3
YES
91
>
-P2 : X
<
93
IS DA_I<X
NO
=
84
92
N3
NO
IS DA_I>X
YES
CONTINUE DO LOOP STARTED AT N2
EXIT
A

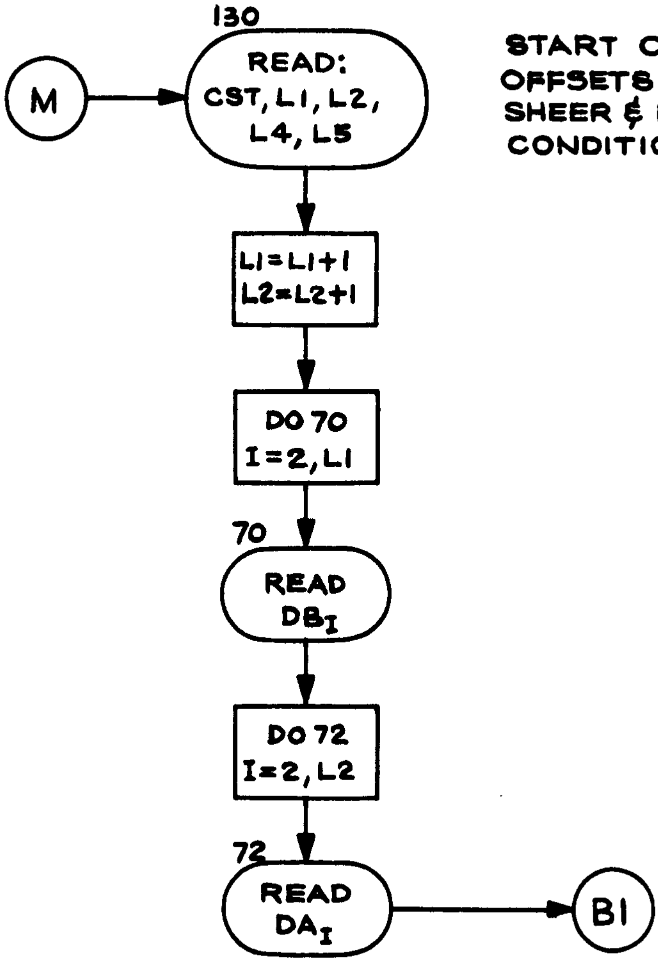

18
K1
ZT=C_{I-1}-AM*(Y-T_I)
PUNCH
Z VALUE
ZT
IF(S.SW.3)
ON
37
ACCEPT
ΔY VALUE
C1
38
Y=Y+C1
IS L3=I
NO
21
IS T_I>Y
NO
YES
17
CONTINUE
DO LOOP
STARTED
AT K
IS T_I<Y
YES
EXIT
29
L1
NO
IS L5>LE
=
-EA_LE:X
YES
>
24
LE=LE+1
25
X=X-V_LE
L


N
IF(S.SW.3)
OFF
ON
766
ACCEPT
ΔY VALUE
CST
67
Y=Y+CST
M3
NO
ISYM<Y
YES
>
<
E$_{LE}$:X
=
78
IS L4>LE
79
LE=LE+1
80
X=X+V$_{LE}$
M2
YES
83
PI:X
>
IS DB$_I$>X
NO
=
74
82
IS DB$_I$<X
YES
CONTINUE
DO LOOP
STARTED
AT M
EXIT
N1
NO

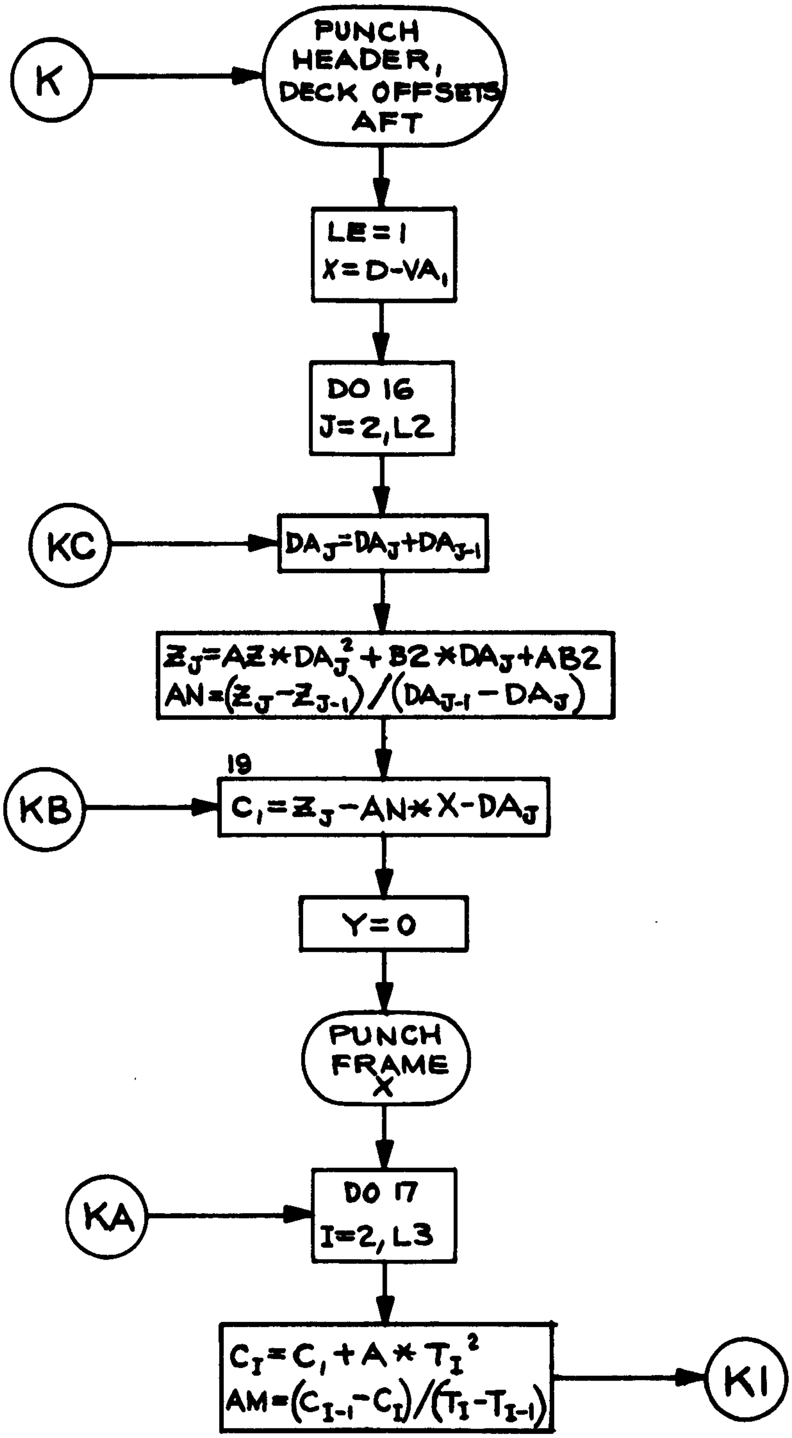

N1
PUNCH HEADER DECK OFFSETS AFT
LE = 1
X = D-VA_LE
N2
DO 84
I = 2, L2
DA_I = -DA_I + DA_I-1
Z_I = A2×DA_I^2 + B2 * DA_I + AB2
AN = (Z_I - Z_I-1) / (DA_I-1 - DA_I)
85
N3
C_1 = Z_I - AN * (X-DA_I)
Y = 0
PUNCH FRAME X
86
N4
ZT = C_1 - A * Y^2
PUNCH Z VALUE ZT
P

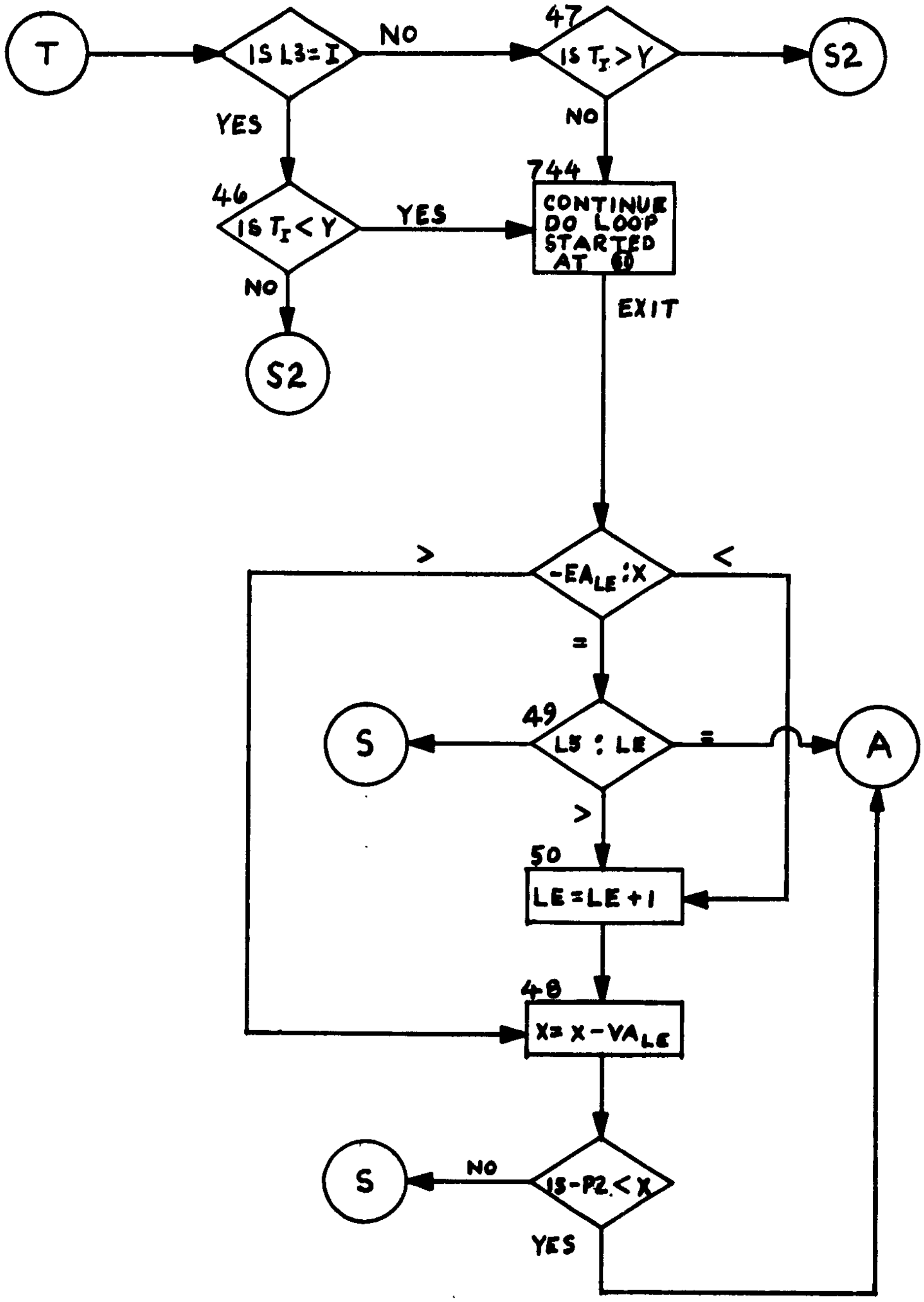

701
Z = HM
DB1 = D
DA1 = D
M1
PUNCH HEADER DECK OFFSETS FORWARD
MA
DO 74
I = 2, L1
DBI = DBI + DBI-1
ZI = A1 * DBI² + B1 * DBI + AB1
AN = (ZI − ZI-1)/(DBI − DBI-1)
75
M2
C1 = ZI-1 + AN * (X − DBI-1)
Y = 0
PUNCH FRAME X
76
M3
ZT = C1 − A * Y²
PUNCH Z VALUE ZT
N

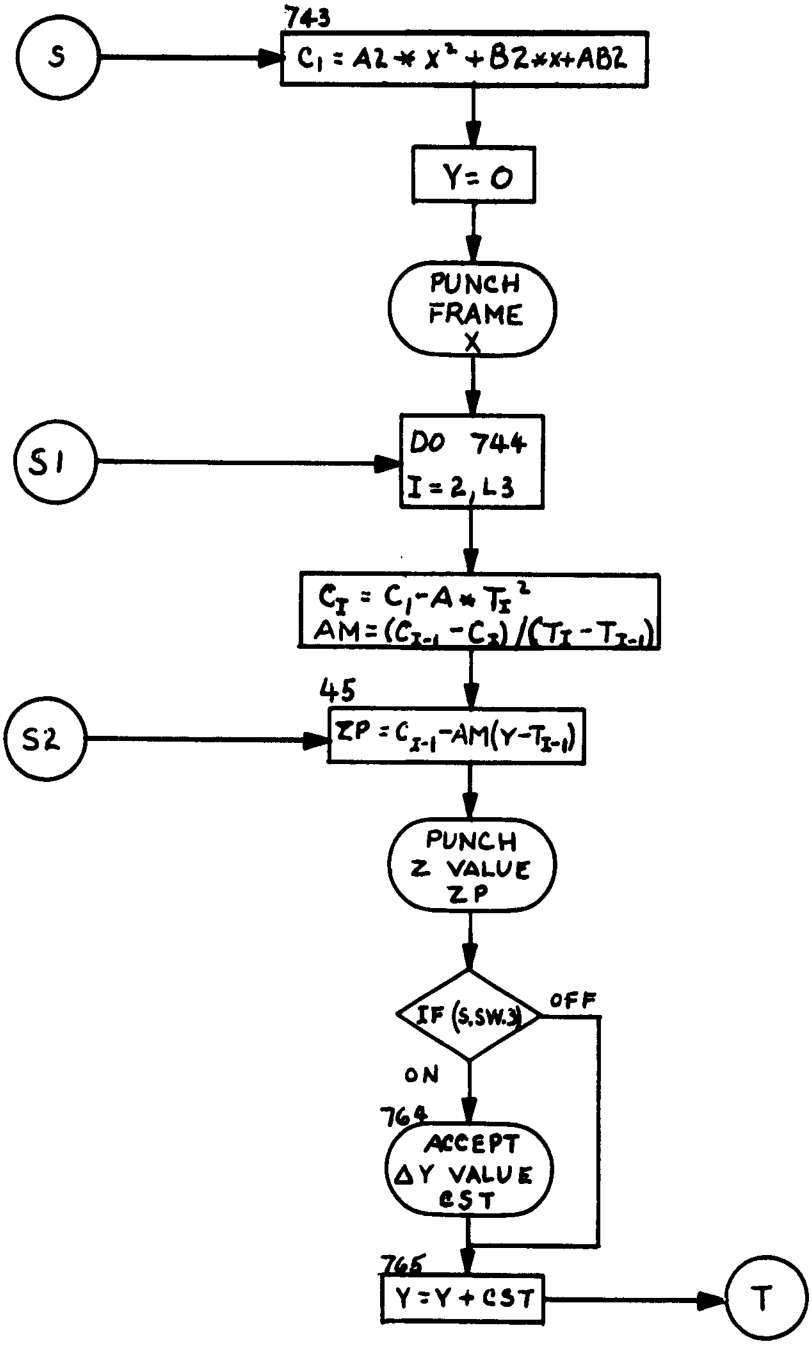


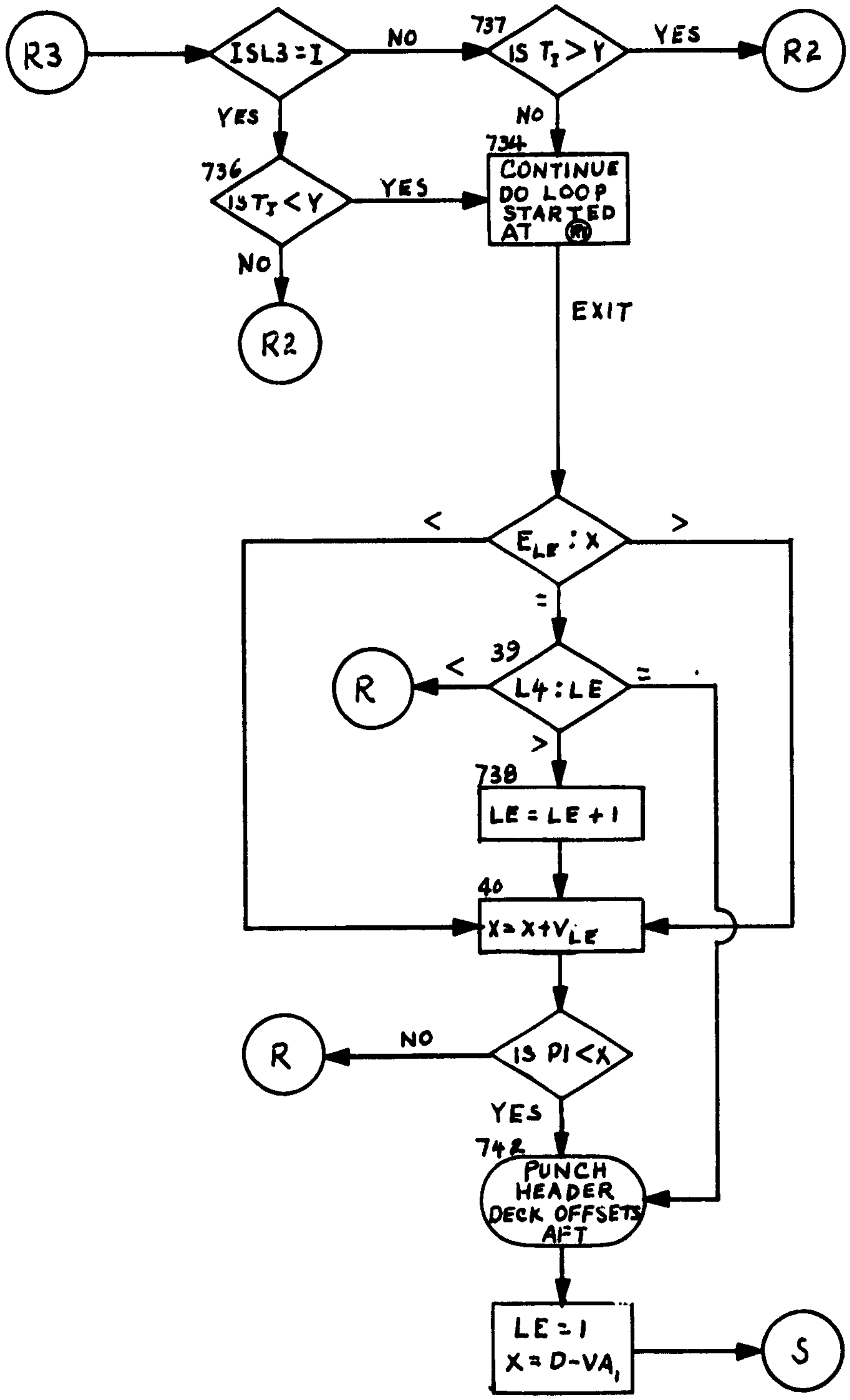


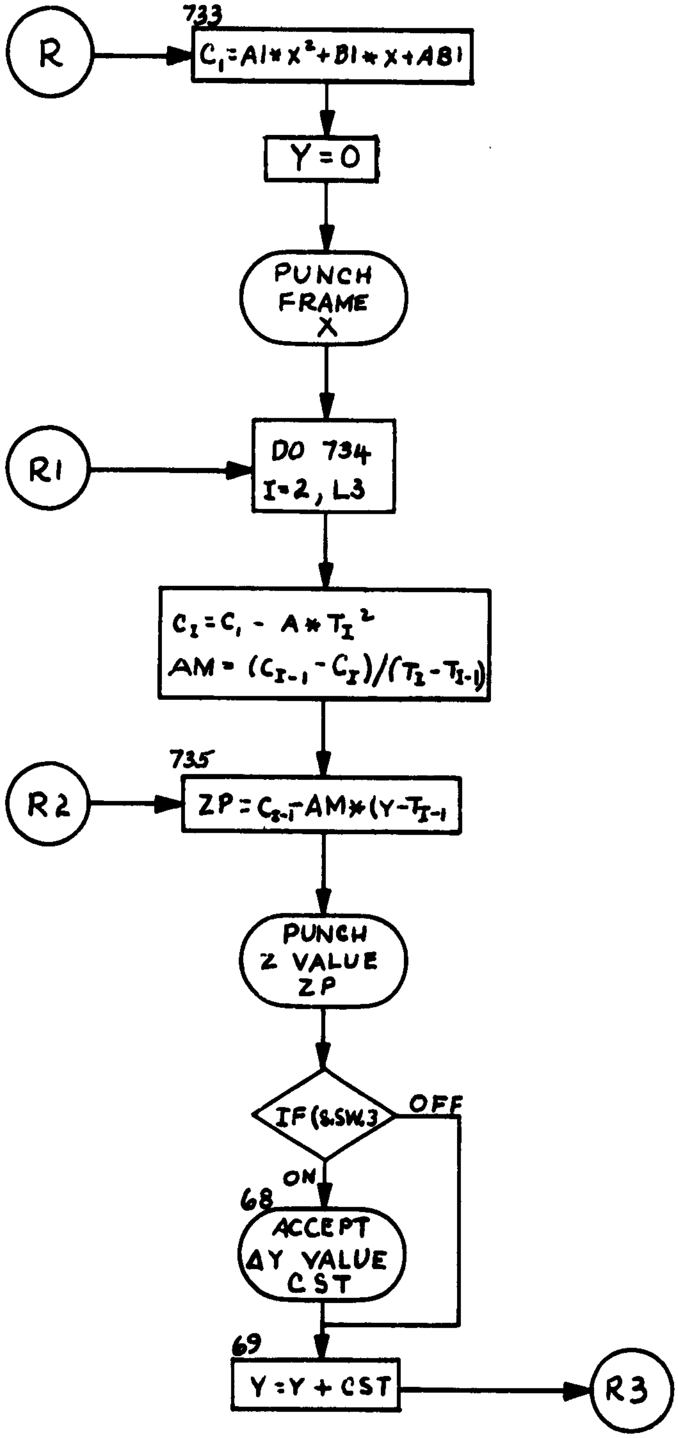
START CALCULATION OF OFFSETS FOR STRAIGHT SHEER & PARABOLIC CAMBER CONDITION

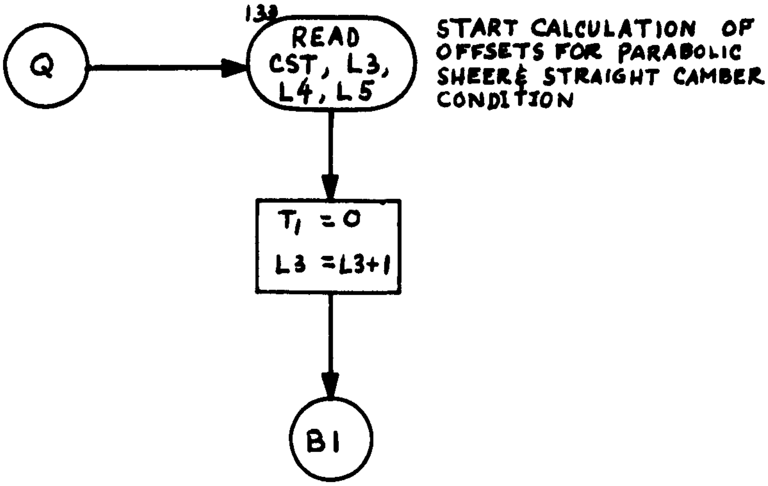

K
PUNCH HEADER, DECK OFFSETS AFT
LE=1
X=D-VA1
DO 16
J=2,L2
KC
DAJ=DAJ+DAJ-1
ZJ=AZ*DAJ2+B2*DAJ+AB2
AN=(ZJ-ZJ-1)/(DAJ-1-DAJ)
19
KB
C1=ZJ-AN*X-DAJ
Y=0
PUNCH FRAME X
KA
DO 17
I=2,L3
CI=C1+A*TI2
AM=(CI-1-CI)/(TI-TI-1)
K1

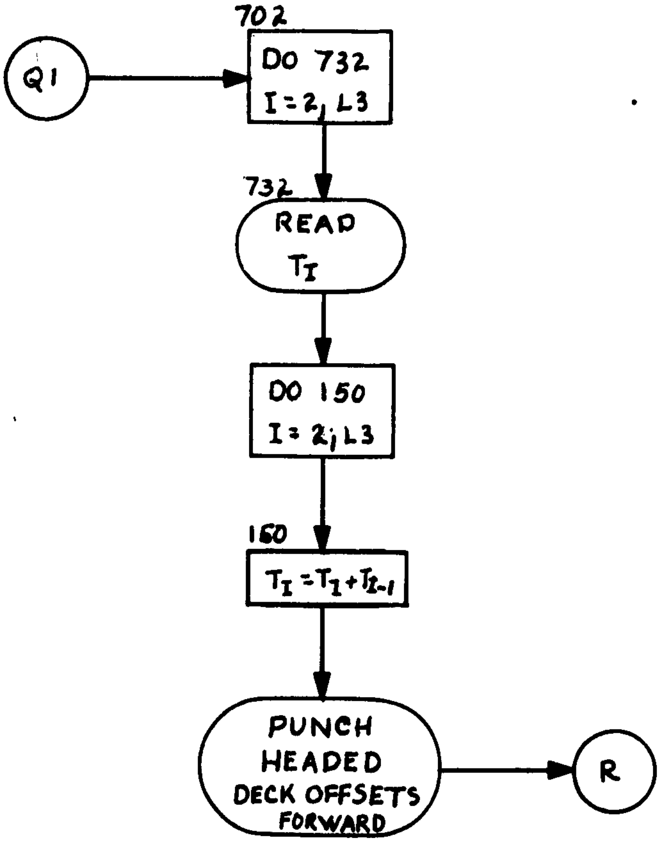

T
IS L3=I
NO
47
IS T_I>Y
S2
YES
NO
46
IS T_I<Y
YES
744
CONTINUE DO LOOP STARTED AT 60
NO
EXIT
S2
>
-EA_{LE}:X
<
=
49
S
L5 : LE
=
A
>
50
LE=LE+1
48
X= X-VA_{LE}
S
NO
IS-P2<X
YES

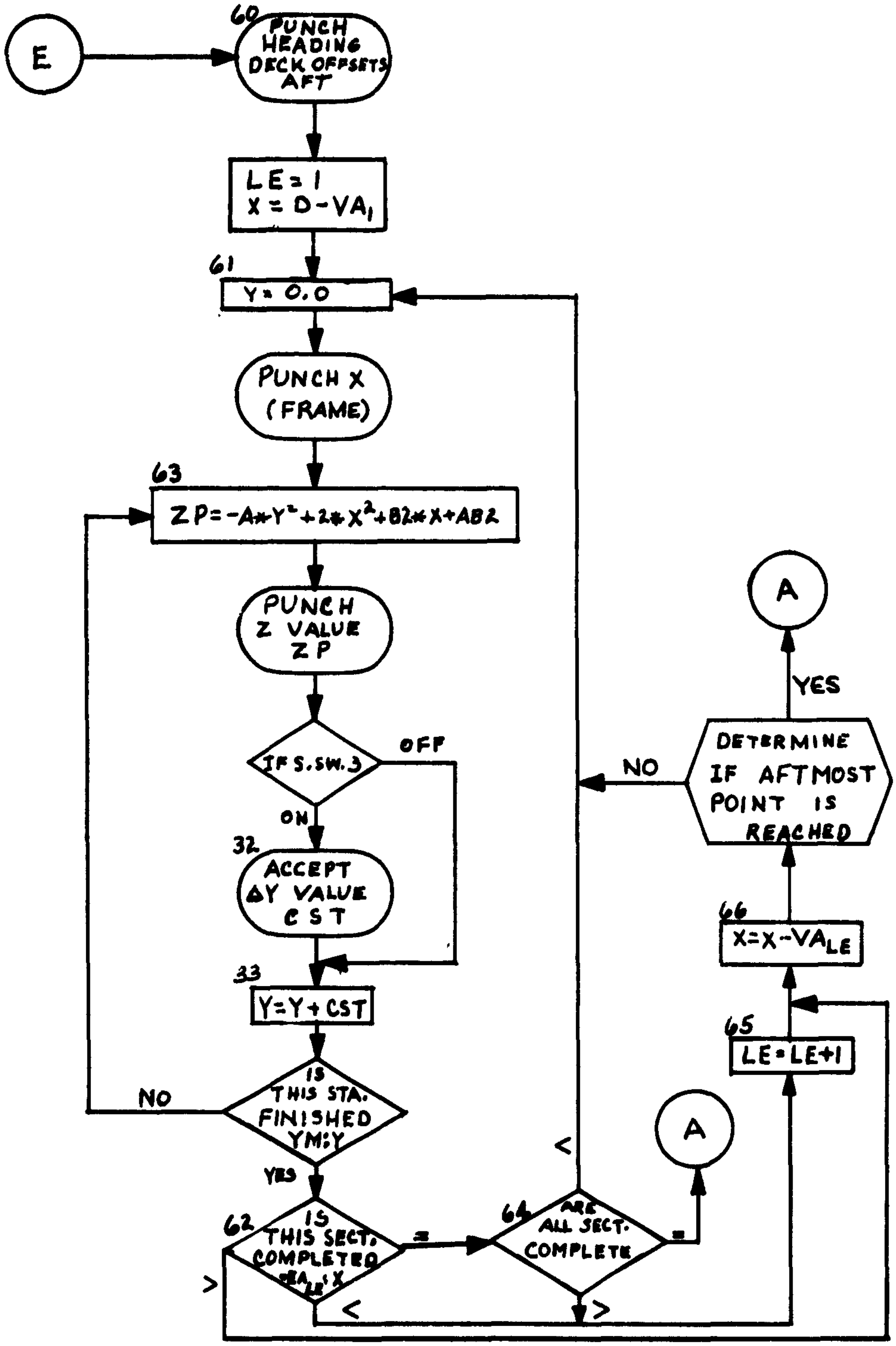

S
743
C1 = A2 * X2 + B2*X+AB2
Y= 0
PUNCH
FRAME
X
S1
DO 744
I = 2, L3
CI = C1-A * TI2
AM=(CI-1 - CI)/(TI - TI-1)
45
S2
ZP = CI-1-AM(Y-TI-1)
PUNCH
Z VALUE
ZP
IF (S.SW.3)
OFF
ON
764
ACCEPT
ΔY VALUE
CST
765
Y = Y + CST
T


R3
ISL3 = I
NO
737
IS T_I > Y
YES
R2
YES
NO
734
736
IS T_I < Y
YES
CONTINUE DO LOOP STARTED AT (R)
NO
R2
EXIT
<
E_{LE} : X
>
=
39
R
<
L4 : LE
=
>
738
LE = LE + 1
40
X = X + V_{LE}
R
NO
IS PI < X
YES
742
PUNCH HEADER DECK OFFSETS AFT
LE = 1
X = D - VA_1
S


R
733
C1=A1*X²+B1*X+AB1
Y=0
PUNCH FRAME X
R1
DO 734 I=2, L3
CI=C1 - A*TI²
AM=(CI-1 - CI)/(TI - TI-1)
735
R2
ZP=CI-1-AM*(Y-TI-1
PUNCH Z VALUE ZP
IF (S.SW.3
OFF
ON
68
ACCEPT ΔY VALUE CST
69
Y=Y+CST
R3


Q
133
READ
CST, L3,
L4, L5
START CALCULATION OF
OFFSETS FOR PARABOLIC
SHEER & STRAIGHT CAMBER
CONDITION
T1 = 0
L3 = L3+1
B1


Q1
702
DO 732
I = 2, L3
732
READ
TI
DO 150
I = 2, L3
150
TI = TI + TI-1
PUNCH
HEADED
DECK OFFSETS
FORWARD
R


E
60
PUNCH HEADING DECK OFFSETS AFT
LE = 1
X = D-VA1
61
Y = 0.0
PUNCH X (FRAME)
63
ZP=-A*Y²+2*X²+B2*X+AB2
PUNCH Z VALUE ZP
IF S.SW.3
OFF
ON
32
ACCEPT ΔY VALUE CST
33
Y=Y+CST
NO
IS THIS STA. FINISHED YM:Y
YES
62
IS THIS SECT. COMPLETED
=
64
ARE ALL SECT. COMPLETE
A
<
>
65
LE=LE+1
66
X=X-VALE
DETERMINE IF AFTMOST POINT IS REACHED
YES
A

FORTRAN PROGRAM LISTING

```
C      * * *  DECK OFFSETS  * * *
C      IDNT=1    PARABOLIC SHEER AND CAMBER
C      IDNT=2    STRAIGHT SHEER AND CAMBER
C      IDNT=3    STRAIGHT SHEER AND PARABOLIC CAMBER
C      IDNT=4    PARABOLIC SHEER AND STRAIGHT CAMBER
        DIMENSION DB(21),DA(21),E(20),EA(20),V(20),VA(20),T(21),C(21)
       DIMENSION Z(21)
       LE=1
       GO TO 600
   26  PAUSE 2
  600  READ 506,IDNT
       READ 500,D,PL,P,YM,DIST
       HF=(.2*PL+20.)/12.
       HA=(.1*PL+10.)/12.
       HM=(2.*YM*.24)/12.
       PL2=PL/2.
       PL2SQ=PL2*PL2
       DSQ=D*D
       A=HM/(YM*YM)
       A1=(HF-HM)/(PL2SQ-2.*D*PL2+DSQ)
       A2=(HA-HM)/(PL2SQ+2.*D*PL2+DSQ)
       B1=-2.*D*A1
       B2=-2.*D*A2
       AB1=B1*B1/(4.*A1)+HM
       AB2=B2*B2/(4.*A2)+HM
       P1=PL2+DIST
       P2=P-P1
       GO TO (131,132,130,133),IDNT
  131  READ 502,CST,L4,L5
  34   DO 52 I=1,L4
  52   READ 500,E(I),V(I)
       DO 53 I=1,L5
  53   READ 500,EA(I),VA(I)
       E(1)=E(1)+D
       EA(1)=EA(1)-D
       DO 41 I=2,L4
  41   E(I)=E(I)+E(I-1)
       DO 42 I=2,L5
  42   EA(I)=EA(I)+EA(I-1)
       LE=1
       X=D
       GO TO (43,44,701,702),IDNT
   43  PUNCH 503
  54   Y=0.
       PUNCH 505,X
  56   ZP=-A*Y*Y+A1*X*X+B1*X+AB1
       PUNCH 500,ZP
       IF(SENSE SWITCH 3) 30,31
  30   ACCEPT 500,CST
```

```
31    Y=Y+CST
      IF(YM-Y)55,56,56
55    IF(E(LE)-X)58,57,59
57    IF(L4-LE)54,60,58
58    LE=LE+1
59    X=X+V(LE)
      IF(P1-X)60,54,54
60    PUNCH 504
      LE=1
      X=D-VA(1)
61    Y=0.
      PUNCH 505,X
63    ZP=-A*Y*Y+A2*X*X+B2*X+AB2
      PUNCH 500,ZP
      IF(SENSE SWITCH 3) 32,33
32    ACCEPT 500,CST
33    Y=Y+CST
      IF(YM-Y)62,63,63
62    IF(-EA(LE)-X)66,64,65
64    IF(L5-LE)61,26,65
65    LE=LE+1
66    X=X-VA(LE)
      IF(-P2-X)61,61,26
132   READ 502,C1,L1,L2,L3,L4,L5
      L3=L3+1
      L1=L1+1
      L2=L2+1
      DO 1 I=2,L1
1     READ 500,DB(I)
      DO 3 I=2,L2
3     READ 500,DA(I)
      DO 5 I=2,L3
5     READ 500,T(I)
      GO TO 34
44    DA(1)=D
      DB(1)=D
      Z(1)=HM
      T(1)=0.
      PUNCH 503
      DO 27 I=2,L3
27    T(I)=T(I)+T(I-1)
      DO 6 J=2,L1
      X=DB(J-1)
      DB(J)=DB(J)+DB(J-1)
      Z(J)=A1*DB(J)*DB(J)+B1*DB(J)+AB1
      AN=(Z(J)-Z(J-1))/(DB(J)-DB(J-1))
8     C(1)=Z(J-1)+AN*(X-DB(J-1))
```

```
      Y=0.
      PUNCH 505,X
      DO 7 I=2,L3
      C(I)=C(1)-A*T(I)*T(I)
      AM=(C(I-1)-C(I))/(T(I)-T(I-1))
9     ZT=C(I-1)-AM*(Y-T(I-1))
      PUNCH 500,ZT
      IF(SENSE SWITCH 3) 35,36
35    ACCEPT 500,C1
36    Y=Y+C1
      IF(L3-I)11,10,11
10    IF(T(I)-Y)7,9,9
11    IF(T(I)-Y)7,7,9
7     CONTINUE
      IF(E(LE)-X)12,28,13
28    IF(L4-LE)6,6,12
12    LE=LE+1
13    X=X+V(LE)
      IF(L1-J)15,14,15
14    IF(DB(J)-X)6,8,8
15    IF(DB(J)-X)6,6,8
6     CONTINUE
      PUNCH 504
      LE=1
      X=D-VA(1)
      DO 16 J=2,L2
      DA(J)=-DA(J)+DA(J-1)
      Z(J)=A2*DA(J)*DA(J)+B2*DA(J)+AB2
      AN=(Z(J)-Z(J-1))/(DA(J-1)-DA(J))
19    C(1)=Z(J)-AN*(X-DA(J))
      Y=0.
      PUNCH 505,X
      DO 17 I=2,L3
      C(I)=C(1)-A*T(I)*T(I)
      AM=(C(I-1)-C(I))/(T(I)-T(I-1))
18    ZT=C(I-1)-AM*(Y-T(I-1))
      PUNCH 500,ZT
      IF(SENSE SWITCH 3) 37,38
37    ACCEPT 500,C1
38    Y=Y+C1
      IF(L3-I)21,20,21
20    IF(T(I)-Y)17,18,18
21    IF(T(I)-Y)17,17,18
17    CONTINUE
      IF(-EA(LE)-X)25,29,24
29    IF(L5-LE)16,16,24
24    LE=LE+1
```

```
25   X=X-VA(LE)
     IF(L2-J)23,22,23
22   IF(DA(J)-X)19,19,16
23   IF(DA(J)-X)19,16,16
16   CONTINUE
     GO TO 26
130  READ 502,CST,L1,L2,L4,L5
     L1=L1+1
     L2=L2+1
     DO 70 I=2,L1
70   READ 500,DB(I)
     DO 72 I=2,L2
72   READ 500,DA(I)
     GO TO 34
701  Z(1)=HM
     DB(1)=D
     DA(1)=D
     PUNCH 503
     DO 74 I=2,L1
     DB(I)=DB(I)+DB(I-1)
     Z(I)=A1*DB(I)*DB(I)+B1*DB(I)+AB1
     AN=(Z(I)-Z(I-1))/(DB(I)-DB(I-1))
75   C(1)=Z(I-1)+AN*(X-DB(I-1))
     Y=0.
     PUNCH 505,X
76   ZT=C(1)-A*Y*Y
     PUNCH 500,ZT
     IF(SENSE SWITCH 3)766,67
766  ACCEPT 500,CST
67   Y=Y+CST
     IF(YM-Y)77,76,76
77   IF(E(LE)-X)79,78,80
78   IF(L4-LE)74,74,79
79   LE=LE+1
80   X=X+V(LE)
81   IF(P1-X)74,82,83
82   IF(DB(I)-X)74,75,75
83   IF(DB(I)-X)74,74,75
74   CONTINUE
     PUNCH 504
     LE=1
     X=D-VA(LE)
     DO 84 I=2,L2
     DA(I)=-DA(I)+DA(I-1)
     Z(I)=A2*DA(I)*DA(I)+B2*DA(I)+AB2
     AN=(Z(I)-Z(I-1))/(DA(I-1)-DA(I))
85   C(1)=Z(I)-AN*(X-DA(I))
     Y=0.
```

```
      PUNCH 505,X
86    ZT=C(1)-A*Y*Y
      PUNCH 500,ZT
      IF(SENSE SWITCH 3) 762,763
762   ACCEPT 500,CST
763   Y=Y+CST
      IF(YM-Y)87,86,86
87    IF(-EA(LE)-X)90,88,89
88    IF(L5-LE)84,84,89
89    LE=LE+1
90    X=X-VA(LE)
91    IF(-P2-X)93,92,84
92    IF(DA(I)-X)85,85,84
93    IF(DA(I)-X)85,84,84
84    CONTINUE
      GO TO 26
133   READ 502,CST,L3,L4,L5
      T(1)=0.
      L3=L3+1
      GO TO 34
702   DO 732 I=2,L3
732   READ 500,T(I)
      DO 150 I=2,L3
150   T(I)=T(I)+T(I-1)
      PUNCH 503
733   C(1)=A1*X*X+B1*X+AB1
      Y=0.
      PUNCH 505,X
      DO 734 I=2,L3
      C(I)=C(1)-A*T(I)*T(I)
      AM=(C(I-1)-C(I))/(T(I)-T(I-1))
735   ZP=C(I-1)-AM*(Y-T(I-1))
      PUNCH 500,ZP
      IF(SENSE SWITCH 3)68,69
68    ACCEPT 500,CST
69    Y=Y+CST
      IF(L3-I)737,736,737
736   IF(T(I)-Y)734,735,735
737   IF(T(I)-Y)734,734,735
734   CONTINUE
      IF(E(LE)-X)738,39,40
39    IF(L4-LE)733,742,738
738   LE=LE+1
40    X=X+V(LE)
      IF(P1-X)742,733,733
742   PUNCH 504
      LE=1
      X=D-VA(1)
```

```
743 C(1)=A2*X*X+B2*X+AB2
    Y=0.
    PUNCH 505,X
    DO 744 I=2,L3
    C(I)=C(1)-A*T(I)*T(I)
    AM=(C(I-1)-C(I))/(T(I)-T(I-1))
45  ZP=C(I-1)-AM*(Y-T(I-1))
    PUNCH 500,ZP
    IF(SENSE SWITCH 3) 764,765
764 ACCEPT 500,CST
765 Y=Y+CST
    IF(L3-I)47,46,47
46  IF(T(I)-Y)744,45,45
47  IF(T(I)-Y)744,744,45
744 CONTINUE
    IF(-EA(LE)-X)48,49,50
49  IF(L5-LE)743,741,50
50  LE=LE+1
48  X=X-VA(LE)
51  IF(-P2-X)743,743,741
741 GO TO 26
500 FORMAT(5F15.9)
502 FORMAT(F15.9,5I5)
503 FORMAT (22HDECK OFFSETS FORWARD.-)
504 FORMAT (18HDECK OFFSETS AFT.-)
505 FORMAT(6HFRAME ,F10.4)
506 FORMAT (2I5)
    END
```

Appendix J

PROGRAM FOR INNER EDGE OF WEB FRAMES

CONTENTS

Appendix J

PROGRAM FOR INNER EDGE OF WEB FRAMES

The purpose of this program is to find the inner contour of a web frame when given offsets describing the mold line contour of the frame. That is, given a set of points which lie on a smooth mold line of a frame, we wish to apply a transformation to these points. This transformation is to be such that the transformed points lie on a curve which is similar in contour but which now passes an ordinate distance C_1 from the upper point and C_2 from the lowest point. (See Fig. J-1a.)

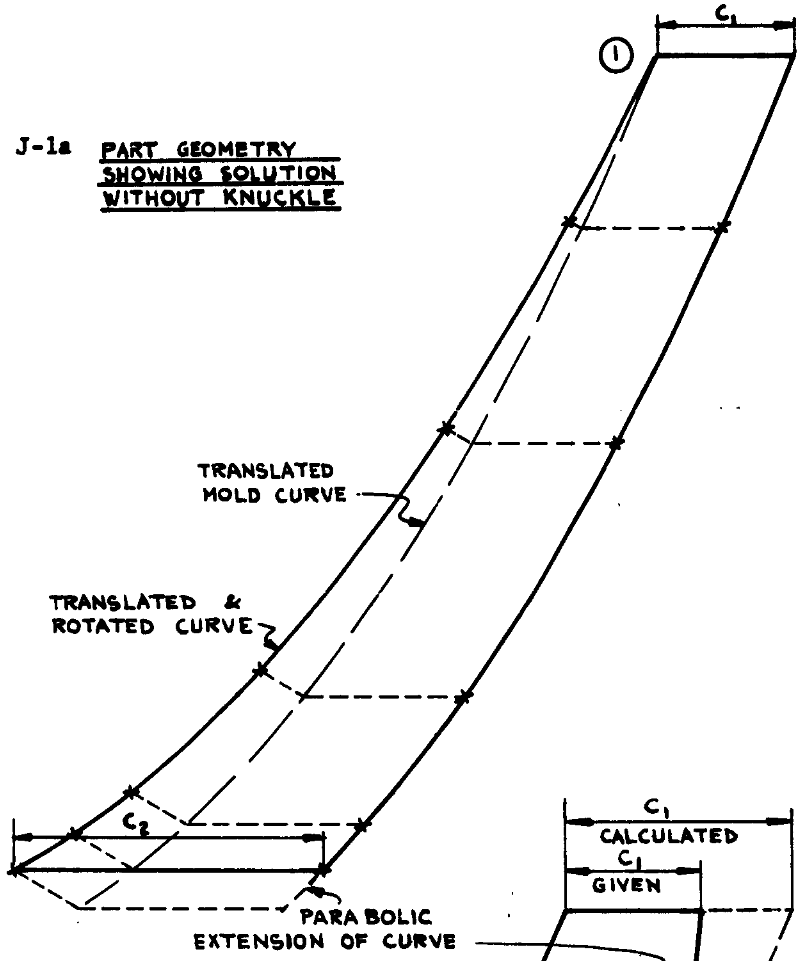
To accomplish this transformation, the curve is first translated the distance C_1 . By examining Fig. J-1a it can be seen that if the curve is now rotated so that the end point was a distance C_2 from its original position, the resulting curve would be too short and in a distorted position. To overcome this condition the curve is extended by fitting a parabola to the three lowest data points and extrapolating a new end point.

A special condition which may sometimes be found on web frames is the existence of a knuckle near the upper point. This condition is illustrated in Fig. J-1b. The inner contour will be a smooth curve from the beginning at the upper edge. The true distance to which the points below the knuckle must be translated is not given by C_1 . Therefore, a new C_1 must be calculated which gives a closer approximation of the correct distance.

The new distance C_1 is approximated by passing a parabola through the uppermost three data points below the knuckle, or if given including the point at the knuckle itself, C_1 can then be found by solving for the point on the parabola corresponding to the upper frame edge.

The program is written in FORTRAN for the IBM-1620 computer.

Fig. J-1a PART GEOMETRY SHOWING SOLUTION WITHOUT KNUCKLE



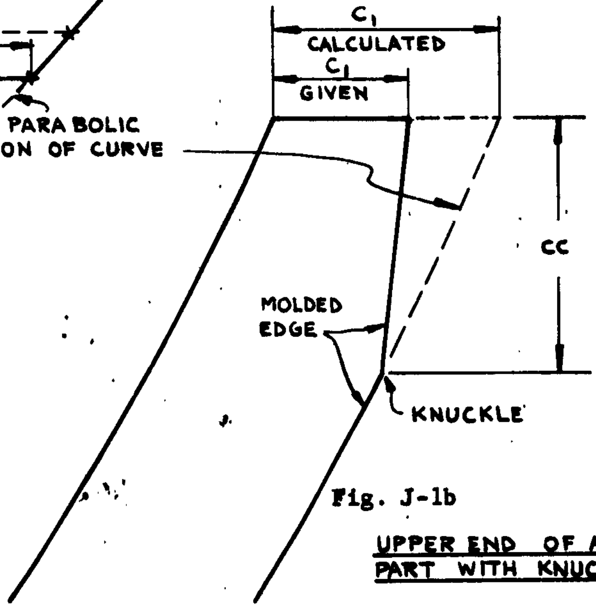


Fig. J-1b

UPPER END OF A PART WITH KNUCKLE

a. Input Data

FORTRAN Input Symbols

N = Number of points, must be an integer with no decimal point, and must be right justified to Column 5. $N \leq 25$

C1 = Ordinate distance curve is to be moved at first point

C2 = Ordinate distance curve is to be moved at last point

CC = Abscissa distance from first point to place where C1 is given. This applies only when the curve contains a knuckle

X(I),Y(I) = Coordinates of points describing the curve

Data Cards

There are a total of (N+1) cards

First Card:

Variable	Format	Card Columns
N	I5	1 - 5
C1	3F10.5	6 - 15
C2		16 - 25
CC		26 - 35

If Sense Switch 1 is OFF, CC will be ignored and nothing need be punched in Columns 26 - 35.

Remaining (N) cards:

Variable	Format	Card Columns
X(I)	2F15.6	1 - 15
Y(I)		16 - 30

b. Sense Switch Settings

Switch 1 ON - Frame Curve contains a knuckle

Switch 1 OFF - Frame curve does not contain a knuckle

c. Output (Via Typewriter)

Transformed points (X,Y)

SAMPLE PROBLEM

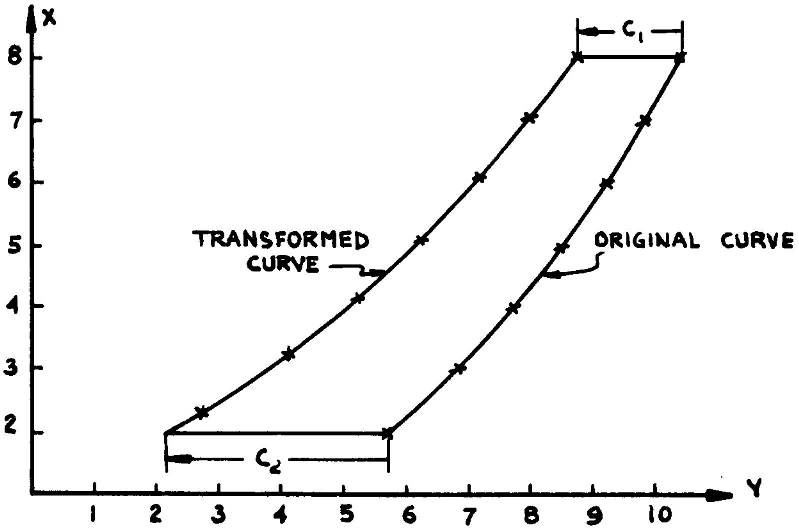
Input

```
 7    -2.0     -3.5
8.0            10.296
7.0             9.758
6.0             9.157
5.0             8.516
4.0             7.853
3.0             7.065
2.0             5.540
```

```
260000200003RS
LOAD DATA
```

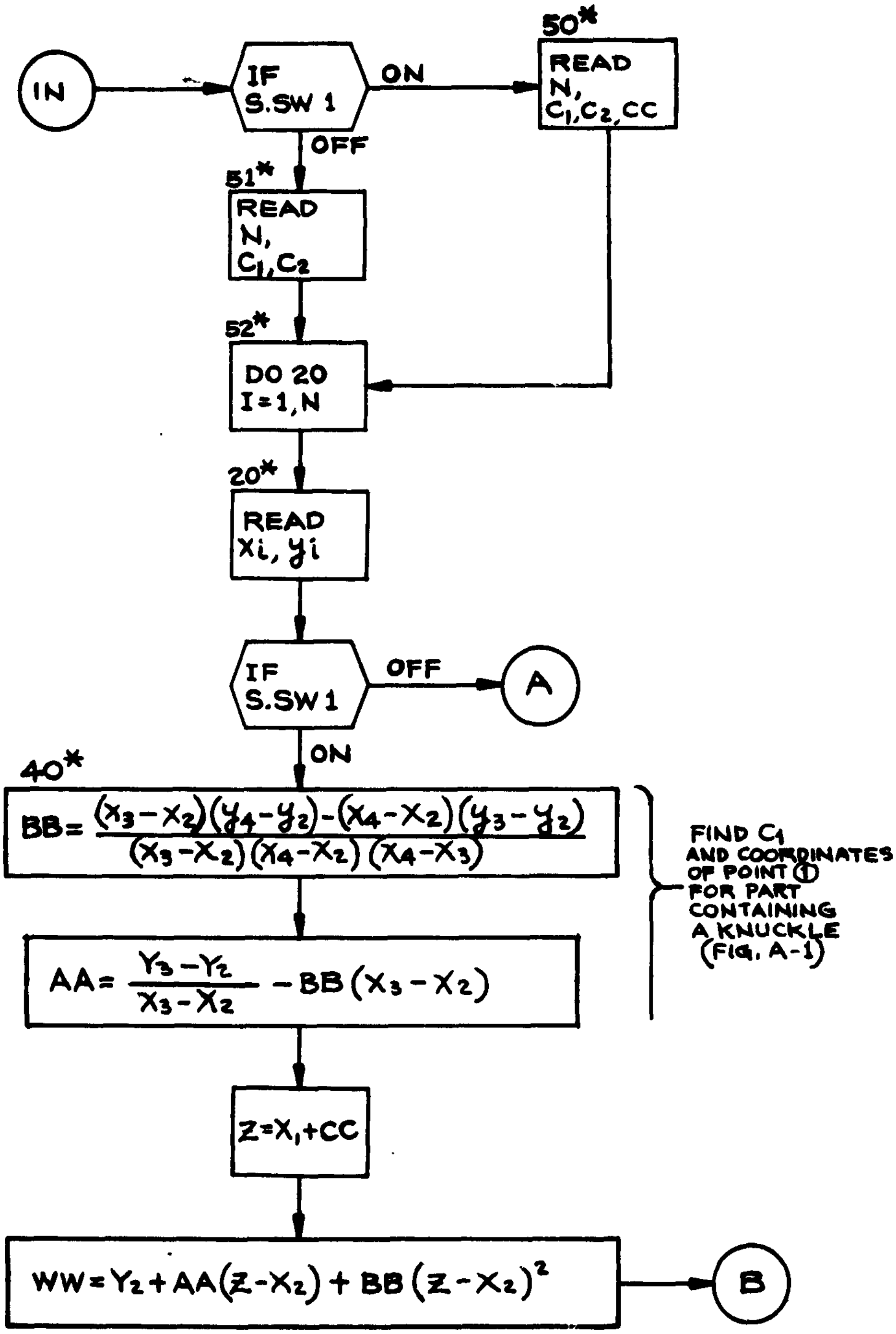
Output

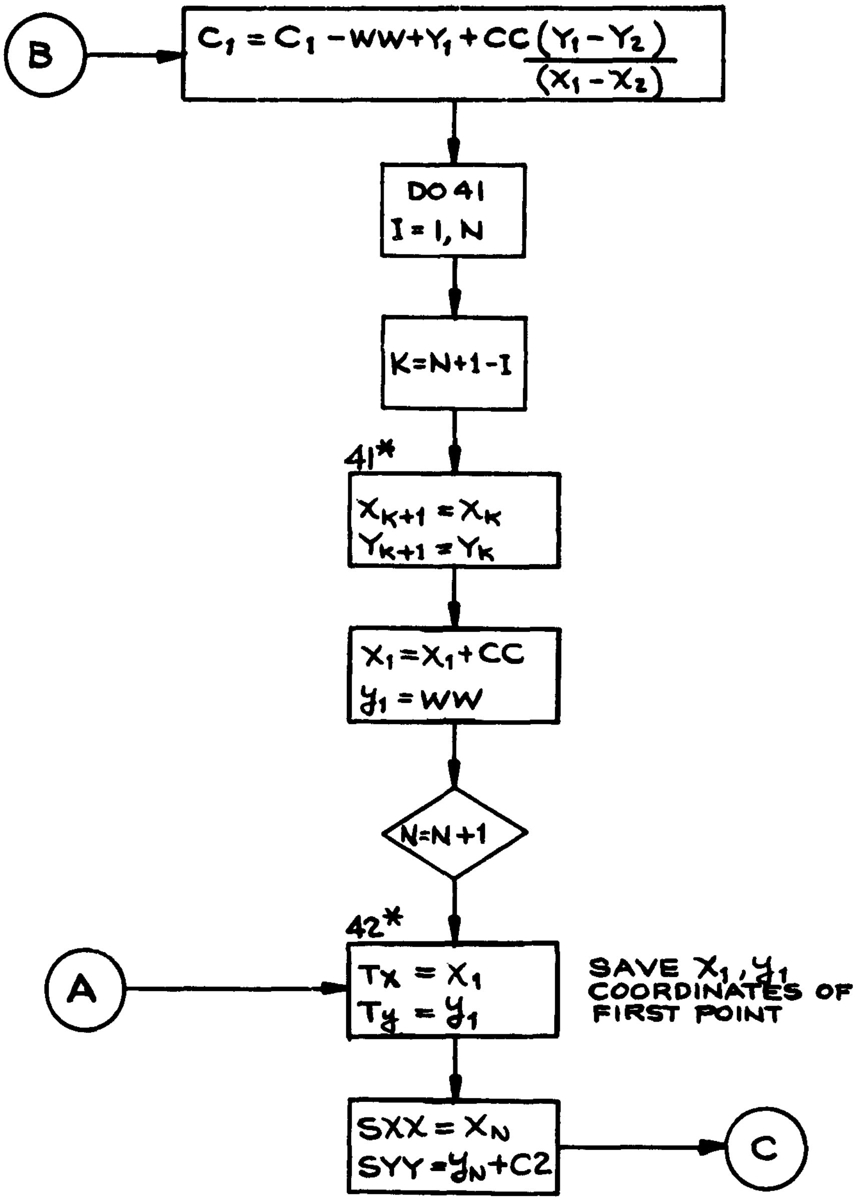
8.000000	8.296000
7.046353	7.679557
6.097758	7.000316
5.152369	6.281204
4.208745	5.540163
3.275142	4.674525
2.400629	3.074258
2.000000	2.040000

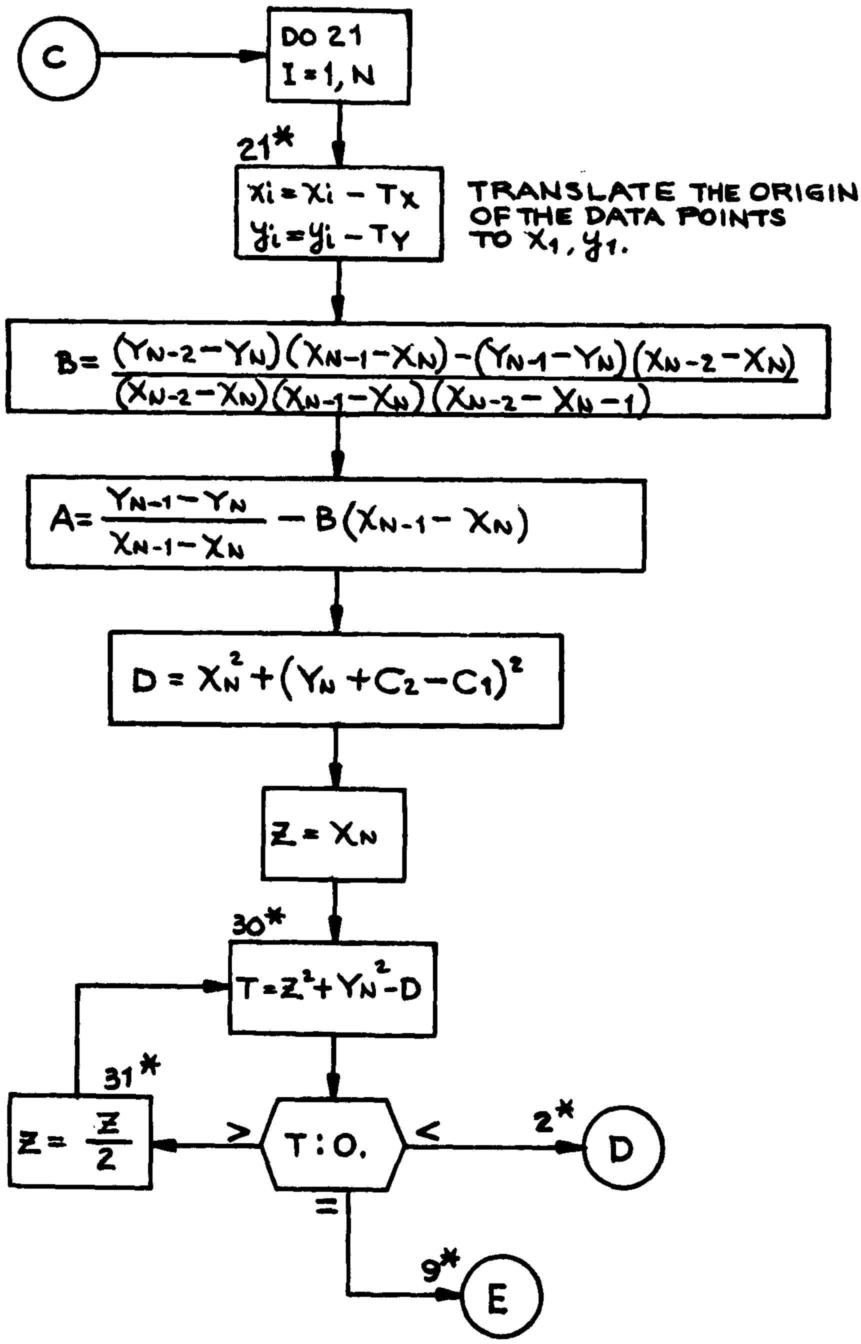


LAYOUT OF SAMPLE PROBLEM.

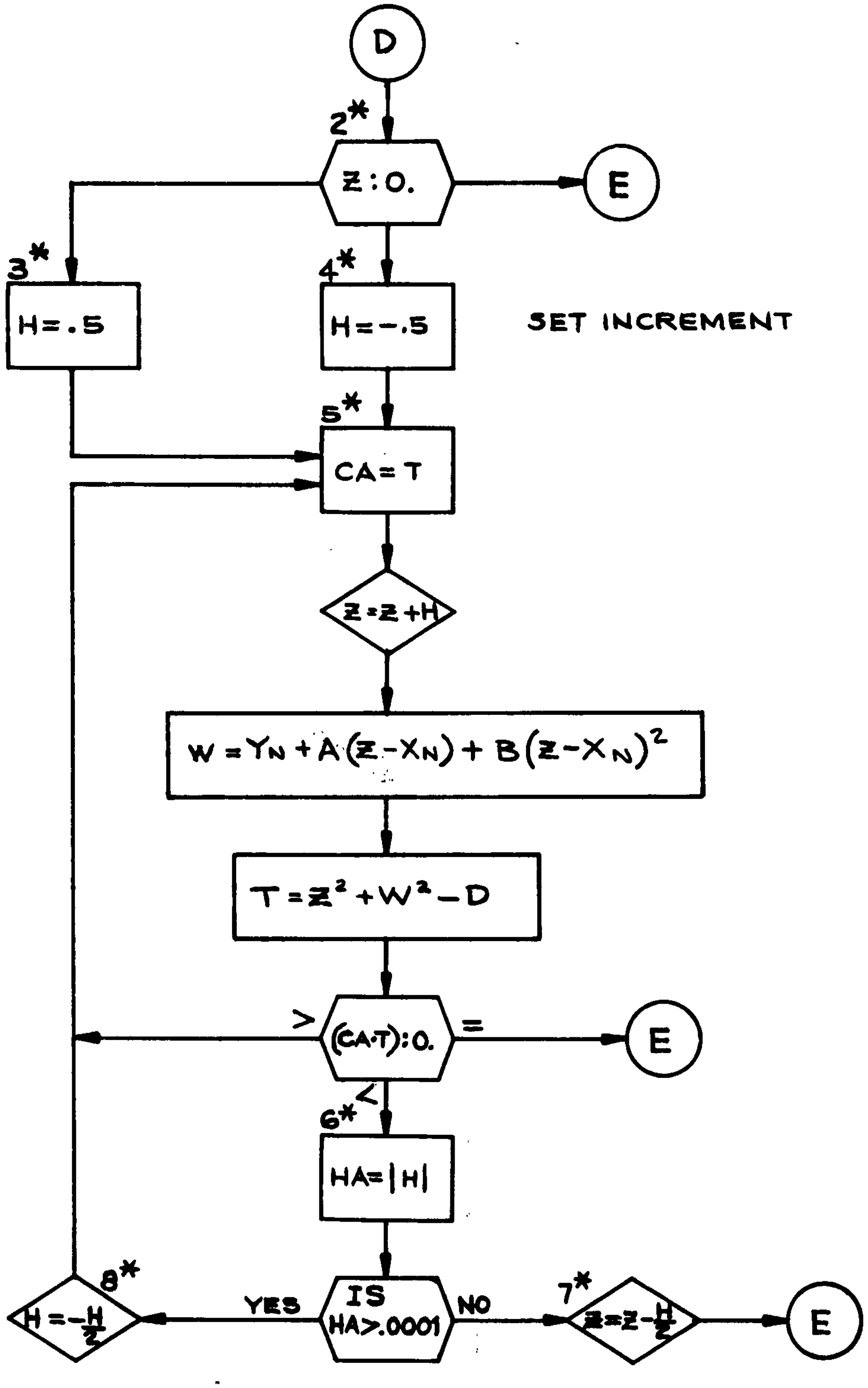
FLOW DIAGRAM

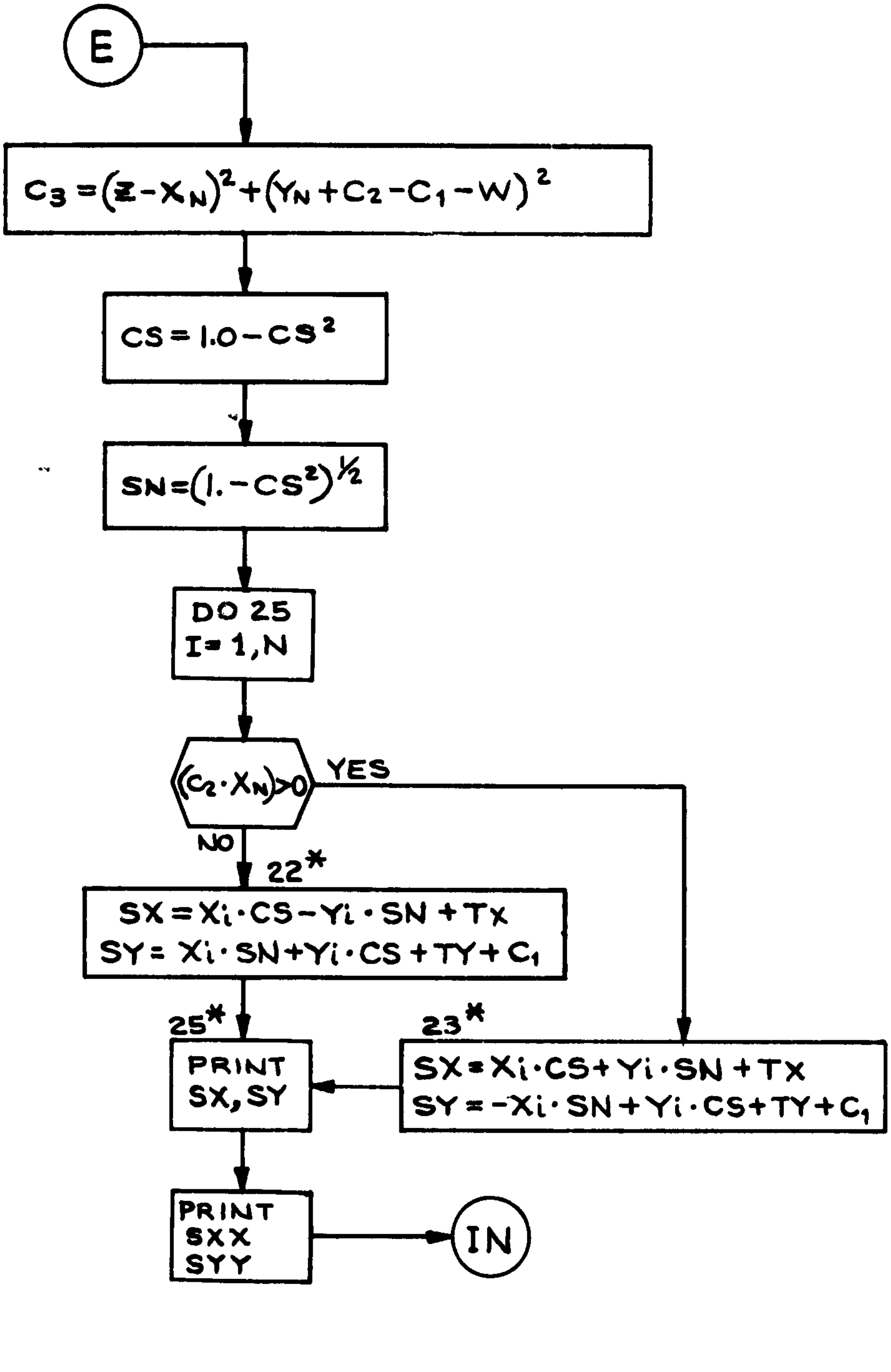



B
C1 = C1 -WW+Y1 + CC (Y1-Y2)/(X1-X2)
DO 41
I = 1, N
K=N+1-I
41*
XK+1 = XK
YK+1 = YK
X1=X1+CC
y1 = WW
N=N+1
42*
A
Tx = X1
Ty = y1
SAVE X1, y1 COORDINATES OF FIRST POINT
SXX = XN
SYY = yN+C2
C



C
DO 21
I = 1, N
21*
xi = Xi − Tx
yi = yi − TY
TRANSLATE THE ORIGIN OF THE DATA POINTS TO X1, y1.
B = (YN-2 − YN)(XN-1 − XN) − (YN-1 − YN)(XN-2 − XN) / (XN-2 − XN)(XN-1 − XN)(XN-2 − XN-1)
A = (YN-1 − YN)/(XN-1 − XN) − B(XN-1 − XN)
D = XN² + (YN + C2 − C1)²
Z = XN
30*
T = Z² + YN² − D
31*
Z = Z/2
>
T : O.
<
2*
D
=
9*
E


D
2*
Z : 0.
E
3*
H = .5
4*
H = -.5
SET INCREMENT
5*
CA = T
Z = Z + H
W = YN + A(Z - XN) + B(Z - XN)²
T = Z² + W² - D
>
(CA-T) : 0.
=
E
<
6*
HA = |H|
8*
H = -H/2
YES
IS HA > .0001
NO
7*
Z = Z - H/2
E


E
C3 =(Z-XN)2+(YN+C2-C1-W)2
CS=1.0-CS2
SN=(1.-CS2)½
DO 25
I= 1,N
(C2·XN)>0
YES
NO
22*
SX=Xi·CS-Yi·SN+TX
SY= Xi·SN+Yi·CS+TY+C1
25*
PRINT
SX,SY
23*
SX=Xi·CS+Yi·SN+TX
SY=-Xi·SN+Yi·CS+TY+C1
PRINT
SXX
SYY
IN

PROGRAM LISTING

```
C       * *  CONTOUR TRANSFORMATION  * *
        DIMENSION X(25),Y(25)
 1      IF(SENSE SWITCH 1)50,51
 50     READ100,N,C1,C2,CC
        GO TO 52
 51     READ 100,N,C1,C2
 52     DO 20 I=1,N
 20     READ101,X(I),Y(I)
        IF(SENSE SWITCH 1)40,42
 40     BB=(X(3)-X(2))*(Y(4)-Y(2))-(X(4)-X(2))*(Y(3)-Y(2))
        BB=BB/((X(3)-X(2))*(X(4)-X(2))*(X(4)-X(3)))
        AA=(Y(3)-Y(2))/(X(3)-X(2))-BB*(X(3)-X(2))
        Z=X(1)+CC
        WW=Y(2)+AA*(Z-X(2))+BB*(Z-X(2))**2
        C1=C1-WW+Y(1)+CC*(Y(1)-Y(2))/(X(1)-X(2))
        DO 41 I=1,N
        K=N+1-I
        X(K+1)=X(K)
 41     Y(K+1)=Y(K)
        X(1)=X(1)+CC
        Y(1)=WW
        N=N+1
 42     TX=X(1)
        TY=Y(1)
        SXX=X(N)
        SYY=Y(N)+C2
        DO 21 I=1,N
        X(I)=X(I)-TX
 21     Y(I)=Y(I)-TY
        B=(Y(N-2)-Y(N))*(X(N-1)-X(N))-(Y(N-1)-Y(N))*(X(N-2)-X(N))
        B=B/((X(N-2)-X(N))*(X(N-1)-X(N))*(X(N-2)-X(N-1)))
        A=(Y(N-1)-Y(N))/(X(N-1)-X(N))-B*(X(N-1)-X(N))
        D=X(N)**2+(Y(N)+C2-C1)**2
        Z=X(N)
 30     T=Z**2+Y(N)**2-D
        IF(T)2,9,31
 31     Z=.5*Z
        GO TO 30
 2      IF(Z)4,9,3
 3      H=.5
        GO TO 5
 4      H=-.5
 5      CA=T
        Z=Z+H
        W=Y(N)+A*(Z-X(N))+B*(Z-X(N))**2
        T=Z**2+W**2-D
        IF(CA*T)6,9,5
```

```
6     HA=ABS(H)
      IF(HA-.0001)7,8,8
7     Z=Z-H/2.
      GO TO 9
8     H=-H/2.
      GO TO 5
9     C3=(Z-X(N))**2+(Y(N)+C2-C1-W)**2
      CS=1.0-.5*C3/D
      SN=SQRT(1.0-CS**2)
      DO 25 I=1,N
      IF(C2*X(N))22,22,23
22    SX=X(I)*CS+Y(I)*SN+TX
      SY=-X(I)*SN+Y(I)*CS+TY+C1
      GO TO 25
23    SX=X(I)*CS-Y(I)*SN+TX
      SY= X(I)*SN+Y(I)*CS+TY+C1
25    PRINT 101,SX,SY
      PRINT 101,SXX,SYY
      GO TO 1
100   FORMAT(I5,3F10.5)
101   FORMAT(2F15.6)
      END
```

Appendix K

ROUTINE FOR IDENTITY MATRICES

CONTENTS

Appendix K

ROUTINE FOR IDENTITY MATRICES

The function of this program is to provide an identity matrix and associated cards for providing a basic feasible solution for the matrices produced by SMOG 1 and SMOG 2.

OPERATING INSTRUCTIONS

The program is written in FORTRAN II for the IBM-1620.

<u>Fortran Input Variable Definitions</u>

IOLM	-	The number of the first column in the "identity" matrix.
IOWS	-	The number of rows in the non-basis matrix produced by SMOG.
COST	-	The cost on the columns of the matrix

<u>Input Format</u>

The input consists of one card with the following format:

Format	I5	I5	F10.4
Variable	IOLM	IOWS	COST

<u>Output</u>

The output is in the following order:

(1) a card punched "BASIS"

(2) A set of basis headings

(3) The identity matrix including the cost row and elements.

<u>Sense Switches</u>

None used

PROGRAM LISTING

```
    1 READ 150,IOLM,IOWS,COST
      PUNCH 151
      IOF=IOLM
      DO 2 I=1,IOWS
      PUNCH 152,IOF,I
    2 IOF=IOF+1
      IOF=IOLM
      DO 3 I=1,IOWS
      PUNCH 153,IOF,COST
      PUNCH 154,IOF,I
    3 IOF=IOF+1
      GO TO 1
  150 FORMAT(I5,I5,F10.4)
  151 FORMAT(5HBASIS)
  152 FORMAT(7X,1HC,I4,2H R,I4)
  153 FORMAT(6X,2H C,I4,6H OFSET,F12.5)
  154 FORMAT(7X,1HC,I4,2H R,I4,8H      1. )
      END
```

SAMPLE INPUT DATA

```
 100   30  1000.0
```

SAMPLE OUTPUT

```
BASIS
         C 100 R      1
         C 101 R      2
         C 102 R      3
         C 103 R      4
         C 104 R      5
         C 105 R      6
         C 106 R      7
         C 107 R      8
         C 108 R      9
         C 109 R     10
         C 110 R     11
         C 111 R     12
         C 112 R     13
         C 113 R     14
         C 114 R     15
         C 115 R     16
         C 116 R     17
         C 117 R     18
         C 118 R     19
         C 119 R     20
         C 120 R     21
         C 121 R     22
         C 122 R     23
         C 123 R     24
         C 124 R     25
         C 125 R     26
         C 126 R     27
         C 127 R     28
         C 128 R     29
         C 129 R     30
         C 100 OFSET    1000.00000
         C 100 R     1     1.0
         C 101 OFSET    1000.00000
         C 101 R     2     1.0
         C 102 OFSET    1000.00000
         C 102 R     3     1.0
         C 103 OFSET    1000.00000
         C 103 R     4     1.0
         C 104 OFSET    1000.00000
         C 104 R     5     1.0
         C 105 OFSET    1000.00000
         C 105 R     6     1.0
         C 106 OFSET    1000.00000
         C 106 R     7     1.0
```

```
C 107 OFSET  1000.00000
C 107 R   8    1.0
C 108 OFSET  1000.00000
C 108 R   9    1.0
C 109 OFSET  1000.00000
C 109 R  10    1.0
C 110 OFSET  1000.00000
C 110 R  11    1.0
C 111 OFSET  1000.00000
C 111 R  12   1.0
C 112 OFSET  1000.00000
C 112 R  13    1.0
C 113 OFSET  1000.00000
C 113 R  14    1.0
C 114 OFSET  1000.00000
C 114 R  15    1.0
C 115 OFSET  1000.00000
C 115 R  16    1.0
C 116 OFSET  1000.00000
C 116 R  17    1.0
C 117 OFSET  1000.00000
C 117 R  18    1.0
C 118 OFSET  1000.00000
C 118 R  19    1.0
C 119 OFSET  1000.00000
C 119 R  20    1.0
C 120 OFSET  1000.00000
C 120 R  21    1.0
C 121 OFSET  1000.00000
C 121 R  22    1.0
C 122 OFSET  1000.00000
C 122 R  23    1.0
C 123 OFSET  1000.00000
C 123 R  24    1.0
C 124 OFSET  1000.00000
C 124 R  25    1.0
C 125 OFSET  1000.00000
C 125 R  26    1.0
C 126 OFSET  1000.00000
C 126 R  27    1.0
C 127 OFSET  1000.00000
C 127 R  28    1.0
C 128 OFSET  1000.00000
C 128 R  29    1.0
C 129 OFSET  1000.00000
C 129 R  30    1.0
```